PROCEEDINGS

OF THE

PENNSYLVANIA ACADEMY OF SCIENCE

VOLUME I

1924-1926

HARRISBURG, PENNSYLVANIA
1926

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PENNSYLVANIA ACADEMY OF SCIENCE

HISTORY OF ORGANIZATION

At various times in the past interest has been expressed in the organization of a Pennsylvania Academy of Science, but the first active steps were taken in this matter when the American Association for the Advancement of Science met at Cincinnati, December, 1923. Among the thousands of scientists in attendance from various States was a considerable representation from Pennsylvania, several of whom got together and discussed the possibilities for such an organization. It was there decided to canvass the State as far as possible and if the idea met with sufficient approval, to call a meeting for the purpose of considering further steps in organization. A committee consisting of C. R. Orton, Pennsylvania State College, E. M. Gress and W. A. McCubbin, Pennsylvania Department of Agriculture, agreed to direct a canvass of the persons connected with the colleges, schools and State departments to ascertain the extent of interest among scientists in organizing such a society. The following persons were present at this meeting at Cincinnati: C. H. Arndt and J. B. Hill, University of Pennsylvania; C. R. Orton, H. E. Hodgkiss, S. W. Frost, F. D. Kern, W. S. Krout, E. L. Nixon, W. S. Beach, and J. P. Kelley, Pennsylvania State College; H. D. Fish, J. L. Cartlege and H. C. Hinshaw, University of Pittsburgh; E. M. Gress, W. A. McCubbin and T. L. Guyton, Pennsylvania Department of Agriculture.

The above mentioned committee sent out over 2,000 questionnaires to persons thought to be interested in organizing an academy. From these questionnaires 123 replies were received, 98 of which were favorable to forming an academy, eighteen not in favor and seven doubtful or indifferent. Encouraged by these replies a call was sent out to these persons to meet in Harrisburg, April 18, 1924, for the purpose of completing the organization.

FIRST MEETING

This meeting was called to order by Frank D. Kern, Pennsylvania State College, and he briefly outlined the purpose of the gathering. A motion was offered and approved that a presiding officer and secretary be selected for the organization meeting. Frank D. Kern was chosen a permanent chairman, and S. H. Derickson, Lebanon Valley College, was chosen as secretary. A motion was then offered that the "Pennsylvania Academy of Science" be organized. After discussion the motion was unanimously passed.

The chairman was authorized to appoint two committees, a committee of three to prepare a constitution, and a committee of five as a nominating committee. The chairman appointed Geo. H. Ashley, G. W. Martin and C. R. Orton to form the Committee on Constitution. B. L. Miller, H. D. Fish, E. M. Gress, F. N. Maxfield and Ralph N. Kocher were placed on the Committee on Nominations.

The Committee on Nominations presented the following names, all of whom were elected as the first officers of the Academy: President, O. E. Jennings, University of Pittsburgh; Vice-president, C. E. McClung, University of Pennsylvania; Secretary, Joseph S. Illick, Pennsylvania Department of Forests and Waters; Assistant Secretary, T. L. Guyton, Pennsylvania Department of Agriculture; Treasurer, Frank D. Kern, Pennsylvania State College; Editor, George H. Ashley, Pennsylvania Department of Forests and Waters; Press Secretary, J. P. Kelley, Pennsylvania State College.

Advisory Council: Gifford Pinchot, Governor of Pennsylvania; Edgar Fahs Smith, Provost Emeritus, University of Pennsylvania; Henry S. Drinker, President Emeritus, Lehigh University; W. J. Holland, Director Emeritus, Carnegie Museum, Pittsburgh.

Executive Committee: O. E. Jennings, President; C. E. McClung, Vice-president; Joseph S. Illick, Secretary; Frank D. Kern, Treasurer; B. L. Miller, Lehigh University, four years; John A. Miller, Swarthmore, two years; S. H. Derickson, Lebanon Valley, one year.

The Committee on Constitution presented a Constitution which was discussed and accepted as a temporary Constitution. The Committee was continued until the next meeting and instructed to present at that time a final draft of a Constitution. A Legislative Committee of two was appointed by the Chairman, J. M. McKee, and John S. Fisher constituted this committee. Upon motion it was decided that all those present at the meeting upon payment of dues would become charter members. The charter member list was held open until the time of adopting a Constitution.

FALL MEETING, 1924

The Executive Committee called a meeting of the Academy on November 28, 1924, O. E. Jennings, presiding, Joseph S. Illick, secretary. The following papers were presented by the members:

Scale insects of Pennsylvania: F. M. Trimble.
Investigation of available road-building materials in Pennsylvania: H. S. Mattimore.
Surveying forest soils: J. T. Auten.
Metal poisoning in peaches: W. A. McCubbin.
Some recent developments in large central stations: Joseph Razek.
Nesting habits of minnows and the pearl organ problem: Norman H. Stewart.

Pre-conceptional sex-control: Harold Dufur Fish.
Foraminiferae in the determination of oil deposits: Geo. H. Ashley.
Serological studies in the control of the hog lung worm: George Zebrowski.
Black granites of northern Bucks County: R. W. Stone.
The rusts of Pennsylvania: C. R. Orton, H. W. Thurston, and F. D. Kern.
The borderlands of science: Benjamin L. Miller.
Need for the expansion of state forests: E. A. Ziegler.
Preliminary notes on a calcified log from the Pittsburgh coal near Morgantown, W. Va.: Charles R. Fettke. (By title.)
Notes on the ecological distribution of some fungi: Hugh M. Raup. (By title.)
An exhibit of models of local geology was shown by Geo. N. C. Henschen.

The Academy was addressed by H. C. Cowles, University of Chicago, on the subject of "State Academies of Science."

Governor Pinchot visited the Academy and expressed a keen interest in the work being done.

The Resolutions Committee reported the following resolutions, which were adopted:

"WHEREAS, the many details essential to the enrollment, edification, and entertainment of the members and friends of the Pennsylvania Academy of Science at the time of the meeting now drawing to a close have been attended to in such a manner as to elicit most complimentary comment from all sources; be it

"*Resolved,* that the Pennsylvania Academy of Science hereby officially express its appreciation and thanks to the members of the several committees whose efforts have contributed so largely to the success of its meetings.

"*Resolved,* that the Pennsylvania Academy of Science officially express its feeling of gratitude and thanks to the Superintendent of Buildings and Grounds for the use of the Senate Caucus Room for the period of the meetings.

"*Resolved,* that the Pennsylvania Academy of Science especially express its gratitude to Dr. H. C. Cowles, University of Chicago, and Dr. Edward Hart, Lafayette College, for their gracious contributions to the success of its meetings.

"*Resolved,* that these resolutions be spread on the minutes of the Academy as a permanent record of appreciation.

(Signed) "RESOLUTION COMMITTEE."

At the Academy dinner held at the Beach Front Hotel Dr. H. C. Cowles, University of Chicago, addressed the Academy on the "Activities of State Academies of Science"; Dr. Edwin Hart, Lafayette College, gave a brief address on the future of the Academy.

THIRD MEETING OF PENNSYLVANIA ACADEMY OF SCIENCE, APRIL 10 AND 11, 1925

The third meeting (the first annual) was held in the Senate Caucus Room, State Capitol, Harrisburg, Pa. The meeting convened on the afternoon of April 10 and was addressed by the president, O. E. Jennings, University of Pittsburgh, on "A Classification of the Plant Societies of Central and Western Pennsylvania." This was followed by the following program:

Sporobolus uniflorus Muhl. in Pennsylvania: E. M. Gress.
Demonstration of the life history of the earthworm: S. Hoffman Derickson.
A double turtle of the genus Chrysemys: S. Hoffman Derickson and V. Earl Light.
Observations on hydra in limestone springs during the winter months: Ray A. Troutman.
Weather conditions at total eclipses of the sun predictable; also notes on the corona: John H. Wayman.
Geographic origin and distribution of the increase of negro population in Pennsylvania: Dean Dutcher.
Problems concerning the formation of calcareous concretions in streams: H. Justin Roddy.
An unusual case of limestone decomposition: Benj. L. Miller.
The energy of high velocity electrons and the variation of their mass with speed: Marsh W. White and W. R. Ham.
Finance and statistic courses administered by the departments of mathematics of Pennsylvania colleges and universities: H. S. Everett.
A study of helicoids and helices by vectors: Joseph B. Reynolds.
Fossil ivory: R. W. Stone.
Observations on peach yellows: W. A. McCubbin and F. L. Holdridge.
Aphids in the transmission of raspberry mosaic: Floyd F. Smith.
The esthetic value of Pennsylvania game birds: Geo. M. Sutton.
A new field of educational research: Richard Hamer.
A possible effect and determination of the earth's rotation: Richard Hamer.
The extent of the Ortho and Parhelium schemes: Richard Hamer.

The publication committee reported progress and outlined a practical plan for the publication of the PROCEEDINGS of the Academy. This committee was authorized to expend up to $300.00 in publishing the PROCEEDINGS up to and including the meetings of April 10–11, 1925.

The incorporation of the Academy was again considered and resubmitted to the Committee on Incorporation to be reported on at the next annual meeting.

The Membership Committee proposed the following names for membership, all of whom were elected to active membership:

Allaman, H. C.
Allaman, R. P.
Aucker, A. A.
Beach, S. W.
Behney, William Hudson
Bonine, C. A.
Carpenter, C. F. Greeves
Christman, William F.
Crawley, Howard
Davis, R. N.

Deck, Ray F.
Durbaker, Dr. L. K.
Dusham, E. H.
Fisher, Harold Y.
Forbes, E. B.
Ford, John J.
Fritz, B. Sceph
Gilbert, Levi
Grove, J. Seth
Guthrie, Mrs. Tracy W.
Hadley, John C.
Hamer, Richard
Herbst, Philip
Highriter, Gordon E.
Howe, Homer B.
Howe, Lloyd E.
Koronkiewicz, Frank S.
Knolancheek, Francis
Krebs, L. C.
Kunkle, J. H.
Kuntz, E. E.
Light, L. Lloyd
Light, V. Earl
Marble, L. M.
Martin, Ralph E.
Maxwell, R. B.
Merchitis, Miss Agnes
Mohler, John Fred.
Morse, E. M.
Peter, Bro. Felician
Pinney, Miss Frances
Porter, Thomas L.
Redditt, Bruce H.
Richard, Rev. Brother
Roudabush, Charles E.
Stoughton, Bradley
Smith, Floyd F.
Swartzel, K. D.
Troutman, Roy A.
Watts, R. L.
Weisberger, Edward J.
Wendt, G. L.
Wenstrup, Edward J.
White, Marsh William
Wilson, Della C.

The Committee on Constitution made its report and the amended, temporary Constitution was adopted as a permanent Constitution. The Secretary's and Auditing Committee's reports were accepted.

The Committee on Resolutions presented the following resolutions which were adopted:

REPORT OF THE COMMITTEE ON RESOLUTIONS

As a consequence of our distinct sense of the success of this meeting of the Academy be it

Resolved, First: that we thank the Superintendent of Buildings and Grounds for this courtesy in assigning us to such suitable and comfortable quarters.

Secondly: that we express our sense of the excellent work done by the local committee in providing so well for our comfort and entertainment.

Third: that we realize the marked success of the Program Committee in arranging the work of the sessions of the Academy.

Fourth: that the gratitude of the Society is due its general officers for their untiring efforts between the sessions and at the meetings in laboring to put the Academy on a firm foundation, deserving the esteem of scientists throughout the State.

Fifth: that the success of the meeting already justifies the formation of the Academy;

WHEREAS, there is now on foot a movement petitioning the State to provide for a Bond Issue to furnish funds for the continued addition to the Forest Reserves of the State, be it

Resolved, that we authorize our Secretary to communicate with such State officers and Legislative Committees as may from time to time consider that question our approval of such Bond Issue.

(Signed) S. C. SCHMUCKER,
A. E. MCKEE

The Nominating Committee presented the following names for the officers indicated, all of whom, upon motion, were elected by a ballot cast by the secretary:

President: B. L. Miller, Lehigh University.
Vice-President: H. D. Fish, University of Pittsburgh.
Secretary: T. L. Guyton, Penna. Department of Agriculture.
Assistant Secretary: F. L. Maxfield, Penna. Department of Education.
Treasurer: F. D. Kern, Penna. State College.
Editor: Geo. H. Ashley, Penna. Geological Survey.
Executive Committee: N. H. Stewart, Bucknell University; S. H. Derickson, Lebanon Valley College.

On the evening of April 10, the Academy met at dinner at the Beach Front Hotel. Doctor Samuel C. Schmucker addressed the meeting on "The Scientist's Duty to the Religious World," and Dr. H. D. Fish presented interesting motion pictures of the British Guiana Jungle Laboratory.

REPORT OF MEETING OF EXECUTIVE COMMITTEE OF THE ACADEMY, JUNE 16, 1925

Dr. H. W. Thurston was selected as Acting Treasurer to replace Dr. Frank D. Kern, of State College, who resigned from the position of Treasurer because he was leaving the country on a year's leave of absence.

At a meeting of the Executive Committee, December 18, 1925, Dr. Richard Hamer, University of Pittsburgh, was selected to fill a vacancy in the Executive Committee. Dr. J. A. Foberg, Department of Public Instruction, was appointed Assistant Secretary to fill the vacancy caused by the resignation of Dr. Maxfield. A Program Committee, consisting of W. A. McCubbin, Chairman; M. W. White, R. W. Stone, Thaddeus Bolton, and O. E. Jennings, was appointed. Committee on Local Arrangements: J. A. Foberg, Chairman; Jos. Illick, and E. M. Gress. April 2nd and 3rd, 1926, was fixed as the time for the Annual Meeting of the Academy. The Secretary was instructed to take steps at once to affiliate the Academy with the American Association for the Advancement of Science.

CONSTITUTION OF PENNSYLVANIA ACADEMY OF SCIENCE

ADOPTED APRIL 11, 1925

ARTICLE 1

SECTION 1. This association shall be called the Pennsylvania Academy of Science.

SECTION 2. The objects of this Academy shall be scientific research and the diffusion of knowledge concerning the various departments of science; to promote intercourse between those engaged in scientific work, especially in Pennsylvania; to assist by investigation and discussion in developing and making known the material, educational, and other resources and riches of the Commonwealth; to arrange and prepare for publication such reports of investigation and discussion as may further the aims and objects of the Academy as set forth in these articles.

ARTICLE 2

SECTION 1. Membership in this Academy shall be made up of the following classes: 1. active members; 2. associate members; 3. honorary members, and 4. non-resident members.

SECTION 2. Any person engaged in any department of scientific work, or in any original research in any department of science, shall be eligible to active membership. Active members shall pay an admission fee of two dollars, which shall also cover the first year's membership fee, and thereafter an annual fee of two dollars. Active members who have removed from the Commonwealth may continue as active members by the payment of annual dues.

SECTION 3. Any resident of Pennsylvania interested in science but who does not qualify for active membership may be elected to associate membership. Fees for associate members shall be the same as for active members.

SECTION 4. Honorary members may be elected to this class of membership in the Academy on account of special prominence in science or other branches of learning. They shall be exempt from the payment of dues.

SECTION 5. Any person not residing in Pennsylvania who is eligible to membership in the Academy may be elected to non-resident membership. Such members shall pay the regular admission fee and annual dues.

SECTION 6. Application for membership in any of the foregoing classes shall be referred to a Membership Committee, which shall consider such application and report to the Academy before the election. In any case a three-fourths vote of the active members present at any meeting shall elect to membership.

SECTION 7. The privilege of voting in this Academy shall be restricted to the class of active membership.

ARTICLE 3

SECTION 1. The officers of this Academy shall be chosen by ballot at the annual meeting, and shall hold office one year or until their successors may be chosen. They shall consist of a President, Vice-president, Secretary, Assistant Secretary, Press Secretary, Editor, and Treasurer, who shall perform the duties usually pertaining to their respective offices and in addition, with the ex-Presidents of the Academy, shall constitute an Executive Committee. Additional members of the Executive Committee shall be elected annually, sufficient to bring the total number of such additional members to four, until such time as past Presidents become available. The President shall, at each annual meeting, appoint a Program Committee and a local Arrangements Committee, each of two or more members, which shall prepare the programs and have charge of the arrangements for all meetings for one year. There shall also be a Committee on Publications, consisting of the President, Secretary, and Editor.

SECTION 2. The Academy may also elect an Advisory Council to consist of the Governor of the Commonwealth, and an indefinite number of others as may be determined from year to year.

SECTION 3. The annual meeting of the Academy shall be held during the Easter vacation of each year and at such place as may be determined by the Executive Committee. Other meetings may be called at such time and place as may be decided upon by the Executive Committee. The Executive Committee shall transact any necessary business not especially provided for in this constitution, in the interim between general meetings.

SECTION 4. The regular publications of the Academy shall include the transactions and all other papers deemed suitable by the Committee on Publication. All members shall receive gratis all current publications of the Academy.

SECTION 5. This constitution may be altered or amended at any annual meeting by a favorable vote of three-fourths of the members present, provided that a copy of the proposed amendment shall be sent to all members at least thirty days previous to the annual meeting.

LIST OF MEMBERS OF THE PENNSYLVANIA ACADEMY OF SCIENCE, JANUARY 1, 1926

Allaman, Harrison C., 2321 Green Street, Harrisburg 1925
Allaman, Ransom Perry, 2321 Green St., Harrisburg 1925
Altenderfer, Harry A., Schuylkill College, Reading 1924*
Ashley, Dr. G. H., State Geologist, Harrisburg 1924*
Atkinson, Dr. D. A., 132 Oakwood Ave., West View, Pittsburgh 1924*
Atkinson, Miss Margaretta, Berwyn 1924*
Aucker, A. A., 1401 Capouse Ave., Scranton 1925
Auten, Prof. J. T., State Forest School, Mont Alto 1924*
Baer, Prof. Clarence E., New Castle 1924*
Beach, W. S., Penn. State College, State College 1924*
Behney, Wm. Hudson, 521 Canal Street, Lebanon 1925
Blackwood, Oswald, University of Pittsburgh, Pittsburgh 1925
Bolton, Thaddeus, Temple University, Philadelphia 1924*
Bonine, C. A., State College 1925
Booth, Miss Helen M., 7402 Germantown Ave., Mt. Airy 1924*
Bradley, T. O., McAlevysfort 1924*
Brunner, W. A., 1814 Briggs St., Harrisburg 1924*
Bryner, H. E., Dept. of Forests & Waters, Harrisburg 1925
Burpee, F. E., Bucknell University, Lewisburg 1924*
Carpenter, C. F. Greeves, 316 S. Juniper St., Philadelphia 1925
Cartledge, J. Lincoln, Biology Hall, Univ. of Pittsburgh, Pittsburgh 1924*
Clutton, A. T., Normal School, Slippery Rock 1924*
Cobaugh, Harry B., 1105 Penn Street, Harrisburg 1924*
Copeland, W. A., Carnegie Institute of Technology, Pittsburgh 1924*
Crawford, S. C., Univ. of Pittsburgh, Pittsburgh 1924*
Crawley, Howard, 5239 Wissahickon Ave., Philadelphia 1925
Cretcher, Dr. Leonard H., 6658 Woodwell St., Pittsburgh 1924*
Darbaker, Dr. L. K., 7025 Hamilton Ave., Pittsburgh 1925
Davis, Herbert L., Dickinson College, Carlisle 1924*
Davis, James B., Minersville High School, Minersville 1925
Davis, Mrs. Nelson F., Lewisburg 1924*
Davis, Prof. Nelson F., Bucknell University, Lewisburg 1924*
Davis, R. N., Everhart Museum, Scranton 1925
Deck, Ray F., Fredericksburg 1925
Derickson, S. H., Lebanon Valley College, Annville 1924*
Diamond, Miss Ellen G., 116 E. Fisher Ave., Philadelphia 1924*
Dimit, B. H., Normal School, Slippery Rock 1924*
Donnelly, Miss Julia M., 202 Riley St., Harrisburg 1924*
Doucette, Chas. F., Bureau of Entomology, Washington, D. C. 1924*
Dupler, Prof. A. W., Juniata College, Huntington 1924*
Dusham, E. H., Department of Zoology, State College 1925
Dutcher, Dean, State Forest School, Mont Alto 1924*
Eddy, M. W., 249 W. Louther St., Carlisle 1924*
Edson, Mrs. John Joy, Jr., East Drive, Sewickley 1924*
Eikenberry, W. L., State Normal School, East Stroudsburg 1924*
Eimert, Miss Helen K., 1440 Cayuga Street, Philadelphia 1924*

*Charter Members.

Eisenmenger, Walter S., Albright College, Myerstown 1924*
Emig, W. H., University of Pittsburgh, Pittsburgh 1924*
Everett, H. S., Bucknell University, Lewisburg 1924*
Eyer, John R., Field Laboratory, North East 1924*
Fencil, Calvin F., Lebanon Valley College, Annville 1924*
Ferguson, Prof. J. A., Dept. of Forestry, State College 1924*
Finnigan, Miss Clara M., 100 Rochelle Ave., Wissahickon, Philadelphia 1924*
Fish, H. D., Dept. of Zoology, Univ. of Pittsburgh, Pittsburgh 1924*
Fisher, Geo. E., Susquehanna University, Selinsgrove 1924*
Fisher, Harold Y., Bureau of Foods & Chemistry, Harrisburg 1925
Foberg, J. A., Dept. of Public Instruction, Harrisburg 1924*
Forbes, E. B., Institute of Animal Nutrition, State College 1925
Ford, John J., 520 S. Walnut St., West Chester 1925
Fretz, A. Henry, 400 Reeder St., Easton 1924*
Garman, Miss Laura E., 1606 Penn Street, Harrisburg 1924*
Gilbert, Levi, Shippensburg 1925
Grant, Herbert, State Normal School, Mansfield 1924*
Green, Prof. Geo. R., State College 1924*
Greene, C. N., Bureau of Plant Industry, Harrisburg 1924*
Gress, E. M., Bureau of Plant Industry, Harrisburg 1924*
Grimm, Samuel Oliver, Annville 1924*
Groner, O. S., Bucknell University, Lewisburg 1924*
Grove, J. Seth, Shippensburg 1925
Guthrie, Mrs. Tracy W., Beaver Road at Newberry Lane, Edgeworth, Sewickley 1925
Guyton, T. L., Bureau of Plant Industry, Harrisburg 1924*
Haas, Dr. Francis B., 715 N. 17th St., Harrisburg 1924*
Hadley, C. H., Bureau of Plant Industry, Harrisburg 1924*
Hadley, John C., 106 S. Barnard St., State College 1925
Haldeman, B. A., 31 S. Front St., Harrisburg 1924*
Hamer, Richard, University of Pittsburgh, Dept. of Physics, Pittsburgh 1925
Hart, Dr. Edward, Lafayette College, Easton 1924*
Hartline, Dr. D. S., State Normal School, Bloomsburg 1924*
Hedenburg, Oscar F., 366 Meyran Ave., Pittsburgh 1924*
Hein, Prof. Illo, State Forest School, Mont Alto 1924*
Henn, Arthur W., Carnegie Museum, Pittsburgh 1924*
Henschen, Prof. G. N. C., 269 Herr St., Harrisburg 1924*
Herbst, Philip J., St. Thomas College, Scranton 1925
Herr, Prof. Paul A., Germantown High School, Philadelphia 1924*
Highriter, Gordon E., 875 S. Franklin St., Wilkes-Barre 1925
Hill, Chas. C., U. S. Entomological Laboratory, Carlisle 1924*
Hill, J. Bent, State College 1924*
Hiller, J. Edward, 1711 Derry St., Harrisburg 1924*
Hoffman, J. V., State Forest School, Mont Alto 1924*
Hoke, E. R., Lebanon Valley College, Annville 1924*
Holdridge, F. L., Lancaster, R. D. 7 1924*
Homer, Fred. Leroy, Schenley High School, Pittsburgh 1924*
Hopkins, Rev. M. A., Villanova 1924*
Horich, Franklin J. W., 230 Hamilton St., Harrisburg 1924*
Horn, Clarence A., Schuylkill College, Reading 1924*
Houston, Mrs. Alice, Normal School, Slippery Rock 1924*

Howe, Homer B., Columbia Co., Benton 1925
Howe, Lloyd E., Houtzdale 1925
Hower, Harry S., 5709 Solway St., Pittsburgh 1924*
Illick, J. S., Dept. of Forests & Waters, Harrisburg 1924*
Jacobs, M. W., Jr., Box 910, Harrisburg 1924*
Jennings, O. E., University of Pittsburgh, Pittsburgh 1924*
Joachim, Miss Helen M., Normal School, Slippery Rock 1924*
Kahl, Paul Hugo Isidor, Curator of Entomology, Carnegie Museum, Pittsburgh 1924*
Karsner, Miss Eleanor F., 1320 S. Broad St., Philadelphia 1924*
Keiffer, Miss Hannah A., State Normal School, Shippensburg 1924*
Keiffer, Miss Nora A., State Normal School, Shippensburg 1924*
Keller, Dr. Ida A., 4424 Osage Ave., Philadelphia 1924*
Keller, John W., Dept. of Forests & Waters, Harrisburg 1924*
Kellogg, James W., Box 108, Harrisburg 1924*
Kelly, J. P., State College 1924*
Kern, F. D., State College 1924*
Kirby, R. S., Penna. State College, State College 1924*
Kirk, H. B., Bureau of Plant Industry, Harrisburg 1924*
Kirkpatrick, Miss Aileen M., 414 S. 44th St., Philadelphia 1924*
Knolancheek, Francis, 39 Pike St., Carbondale 1925
Knull, J. N., 1120 N. Seventeenth St., Harrisburg 1924*
Kob, Prof. John F., 1501 Swatara St., Harrisburg 1924*
Kocher, Prof. Ralph, Wyomissing 1924*
Koenig, Dr. Adolph, 1005 Westinghouse Bldg., Pittsburgh 1924*
Koons, Orville F., 3011 Main St., Penbrook 1924*
Koronkiewicz, Frank S., 186 S. Market St., Nanticoke 1925
Krebs, L. C., Shippensburg 1925
Krout, W. S., State College 1924*
Kunkel, Dr. B. W., Lafayette College, Easton 1924*
Kunkle, J. H., 36 S. Green St., E. Stroudsburg 1925
Kuntz, E. E., E. Stroudsburg 1925
Kuntz, W. A., State College 1924*
Kyle, Prof. Frank P., 114 Susquehanna St., Mauch Chunk 1924*
Lauer, K. W., Bureau of Plant Industry, Harrisburg 1924*
Lehighton, Prof. Henry, Dept. of Geology, University of Pittsburgh, Pittsburgh 1924*
Lewis, Brother George, St. Thomas College, Scranton 1924*
Light, L. Lloyd, Annville 1925
Light, V. Earl, Annville, R. D. 3 1925
Lively, Chauncey C., 117 Lookout Ave., Charleroi 1924*
Luckenbach, Martha O., 422 Third Ave., Bethlehem 1925
Mann, Mrs. Edna F., 239 Briggs St., Harrisburg 1924*
Marble, L. M., Canton 1925
Martin, G. W., Washington & Jefferson, Washington 1924*
Martin, Ralph E., 107 Commerce St., Lock Haven 1925
Mattimore, H. S., Department of Highways, Harrisburg 1924*
Maxfield, Francis N., Department of Psychology, Ohio State University, Columbus, Ohio 1924*
Maxwell, R. B., Canton 1925
McCubbin, W. A., Bureau of Plant Industry, Harrisburg 1924*
McGann, A. F., 1919 Swatara St., Harrisburg 1924*

McGinnis, C. S., Temple University, Philadelphia 1924*
McKee, A. E., 356 Rebecca St., Pittsburgh 1924*
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Metzger, H. S., Irvin Building, Williamsport 1924*
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Miller, Mrs. Salome Comstock, Perdix 1924*
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Mohler, Dr. John Fred., Dickinson College, Carlisle 1925
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Morton, T. Roy, Petersburg 1924*
Nelson, E. H., State Normal School, Bloomsburg 1925
Netting, M. Graham, Carnegie Museum, Pittsburgh 1924*
Nicholas, Herbert, Fayetteville, R. D. 2 .... 1924*
Nixon, E. L., Penna. State College, State College 1924*
Ortmann, Dr. A. E., Carnegie Museum, Pittsburgh 1924*
Orton, C. R., State College 1924*
Palmer, C. M., State College 1924*
Penderbaugh, J. F., High School, Lock Haven 1924*
Peter, Bro. Felician, St. Thomas College, Scranton 1925
Pierce, E. F., 302 Center St., Kennett Square 1924*
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Porter, Thomas L., 396 Locust Ave., Washington 1925
Potts, Dr. Geo. C., 1513 North 2nd St., Harrisburg 1924*
Raymond, Mark L., Central High School, Scranton 1924*
Razek, Prof. Joseph, Department of Mechanical Engineering, Towne Scientific School, University of Pennsylvania, Philadelphia 1924*
Redditt, Bruce H., Lebanon Valley College, Annville 1925
Reiff, Miss Ellen, California 1924*
Reimer, W. J., 110 Analomink St., East Stroudsburg 1925
Rex, Edgar J., State College 1924*
Reynolds, Joseph B., 721 West Broad St., Bethlehem 1925
Rial, D. W., Westinghouse High School, Pittsburgh 1924*
Richard, Rev. Brother, St. Thomas College, Scranton 1925
Richards, Dr. C. R., President, Lehigh University, Bethlehem 1924*
Roberts, C. M., 724 Rosedale Ave., Erie 1924*
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Rogers, D. Paul, P. O. Box 277, Progress 1924*
Rothrock, Boyd P., State Museum, Harrisburg 1924*
Ruff, Clay C., Normal School, Slippery Rock 1924*
Rule, Dr. James N., Department of Public Instruction, Harrisburg 1924*
Sanders, J. G., Sun Oil Co., Philadelphia 1924*

Saylor, Robert L., 100 Shell St., Progress 1925
Schmucker, Miss Dorothy, State Normal School, West Chester 1924*
Schmucker, Dr. S. C., Normal School, West Chester 1924*
Shearer, Prof. S. S., Normal School, Shippensburg 1924*
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Shortess, S. Irvine, 426 East Main St., Bloomsburg 1924*
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Silverman, Alexander, University of Pittsburgh, Pittsburgh 1925
Smith, Miss Cora A., 817 Poplar St., Erie 1924*
Smith, Dr. Edgar Fahs, University of Pennsylvania, Philadelphia 1924*
Smith, Floyd F., Bureau of Plant Industry, Harrisburg 1925
Smith, Herbert D., U. S. Entomological Laboratory, Carlisle 1924*
Smith, Wm., Schenley High School, Bigelow Boulevard, Pittsburgh 1924*
Snyder, Chas. F., 1924 State St., Harrisburg 1924*
Sperry, Miss Alice Jane, State Normal School, Slippery Rock 1924*
Stadden, R. W., 618 Main St., Stroudsburg 1924*
Staley, L. E., Department of Forests and Waters, Harrisburg 1924*
Stayer, J. Clyde, 1815 Moore St., Huntingdon 1925
Stear, J. R., 68 North 6th St., Chambersburg 1924*
Stewart, Dr. Douglas, Carnegie Museum, Pittsburgh 1924*
Stewart, Prof. John A., Thiel College, Greenville 1924*
Stewart, Norman H., Bucknell University, Lewisburg 1924*
Stewart, Paul R., Waynesburg College, Waynesburg 1924*
Stichter, G. B., 141 S. 52nd St., Philadelphia 1924*
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Stoughton, Bradley, P. O. Box 567, Bethlehem 1925
Stuart, Geo. A., Bureau of Markets, Department of Agriculture, Harrisburg........ 1924*
Stuart, R. Y., Department of Forests and Waters, Harrisburg 1924*
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Sutton, Geo. M., State Ornithologist, Game Commission, Harrisburg 1924*
Swartzel, K. D., Department of Mathematics, University of Pittsburgh, Pittsburgh. Home: 4360 Center Ave., Pittsburgh 1925
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Trimble, F. M., Bureau of Plant Industry, Harrisburg 1924*
Troutman, Roy A., Lebanon Valley College, Annville 1925
Tschudy, Earl H., 138 South 4th St., Lebanon 1924*
Urban, A. E., 713 Columbia Ave., Lancaster 1924*
Vincent, Arthur P., Normal School, Slippery Rock 1924*
Wachter, W. L., Lafayette College, Easton 1924*
Waldron, Dr. Ralph A., Normal School, Slippery Rock 1924*
Walton, Geo. W., Albright College, Myerstown 1924*
Ward, H. A., 1534 North 4th St., Harrisburg 1924*
Watts, R. L., 215 East Foster Ave., State College 1925
Wayman, John, 38 Cowan St., Pittsburgh 1924*
Weidlein, E. R., Mellon Institute, Pittsburgh 1925

Weirick, Miss Iva C., 803 North 16th St., Harrisburg 1924*
Weisberger, David, 304 North Webster Ave., Scranton 1925
Wendt, Gerald L., State College 1925
Wenstrup, Rev. Edw. J., St. Vincent College, Beatty 1925
Wentzel, Prof. Wm., Schuylkill College, Reading 1924*
White, Marsh William, 222 South Gill St., State College 1925
Williams, John R., Fayetteville, R. D. 2 .... 1924*
Wilson, Della C., Normal School, East Stroudsburg 1925
Wirt, Geo. H., Department of Forests and Waters, Harrisburg 1924*
Yingst, Prof. Wm. Paul, Cleona 1924*
Zebrowski, Prof. Geo., Villanova College, Villanova 1924*
Ziegler, Dr. E. A., State Forest School, Mont Alto 1924*

DECEASED CHARTER MEMBERS

McGrady, Wm. B., Bureau of Standards, Harrisburg, died October 30, 1924.
Myers, P. R., U. S. Entomological Laboratory, Carlisle, died February 12, 1925.
Bryner, H. E., Department of Forests and Waters, Harrisburg, died March 2, 1925.
Peck, Dr. Frederick B., Lafayette College, Easton, died November 2, 1925.

CLASSIFICATION OF THE PLANT SOCIETIES OF CENTRAL AND WESTERN PENNSYLVANIA

(Presidential address)

BY O. E. JENNINGS

The plant geography of central and western Pennsylvania presents some interesting problems. Many plants, such as the persimmon, papaw, sweet azalea, and the mistflower (*Eupatorium coelestinum*) extend into the State from the south and their northern limit is, in general, an east-west line. Other species, such as the white pine, pitch pine, the Ohio buckeye, and the dwarf trillium (*Trillium nivale*), reach either their eastern or western limits in the western part of the State. It is evident that quite different ecological factors are concerned in the problem.

After collecting extensively and studying the plants of western and central Pennsylvania for about twenty years the belief has grown with the writer that the most generally satisfactory basis for the classification of the vegetational groups or plant societies is one mainly concerned with the physiographic development of the State. Such a basis allows for the migrations of plants over and through the region and it allows, also, for the variations of elevation, topography, and nature of the soil, all of which have important bearings on the distribution of plants and their groupings in plant societies of various kinds.

During the Glacial Period, perhaps 50,000 years ago,[1] the ice extended southwards over the northwestern corner of the State as far as Beaver County, about half way down the western State boundary. In front of the ice it is quite likely that there were, compressed into rather narrow zones, much the same belts or zones of vegetation that now cross the northern part of North America in a general east-west direction. There may have been a narrow strip of tundra immediately in front of the ice, but, at least, there was very probably a belt of spruces, tamarack, balsam fir, arbor vitae, etc.; next south of this a mixed forest of white pine, hemlock, sugar maple, beech, etc.; and still farther south, and probably of wide extent and centering about the southern Appalachians, a deciduous forest of broad-leaved trees such as now naturally inhabits the Ohio Valley.[2]

[1] Schuchert, Charles. Text-book of Geology, Part II. Historical Geology, rev. ed. 1924. pp. 648 and 654.

Allison, Vernon C. Quaternic and Tertic Chronology. Pan-Amer. Geol. 42: 199–216. 1924.

[2] Adams, C. C. Post-glacial origin and migrations of the life of Northeastern U. S. Jour. Geog. 1: 308 et seq. 1902.

With the retreat of the ice and the warming up of the country these belts of vegetation expanded and followed each other northwards, and, in fact, are still evidently carrying on this northward migration, the more southern plants taking the places of the northern ones except where, in certain areas, often of small extent, local conditions of topography, exposure, cold soils, cold spring waters, altitude, etc., have kept the southern plants from taking possession. Such local lagging behind on the part of the northerly moving migrants is evident, especially in the northwestern and northeastern (glaciated) corners of the State, where sphagnum-tamarack bogs still remain; also, to a lesser extent, on the elevated plateau of the north-central part and along the central mountain ranges southwards through the State. Due to the circumstance that Pennsylvania lies along the battle-front between the northern coniferous types of vegetation and the more southern broad-leaved forests, and that the varied physiography and topography favor, here the one type and there the other, the vegetation of northern Pennsylvania, particularly, is broken up into irregular and often isolated areas of the one or the other type.

Through the southern half of the State, from the Huntingdon region westward, there are but small areas of the northern types of vegetation remaining, and, for the purposes of a general discussion we may generally characterize this part of Pennsylvania as having been taken over by the more southern broad-leaved type of forest, characterized in various stages of its development by oaks, hickories, maples, beech, etc. As one travels back and forth through this region there seems, at first, to be little system in the organization of the vegetation, here one group, there other groups prevailing, as the topography or other conditions change. However, if one travels from the top of one of the central ridges, such as Tussey Mountain, or Warriors Ridge, near Huntingdon, down the slope to the valley floor, a series of vegetation zones or belts will be traversed and these will, further, be found to be duplicated on practically any of the other high ridges of south-central Pennsylvania. This may well introduce a brief discussion of some of the fundamental principles of ecological plant geography.

Physiographic and Vegetational Cycles

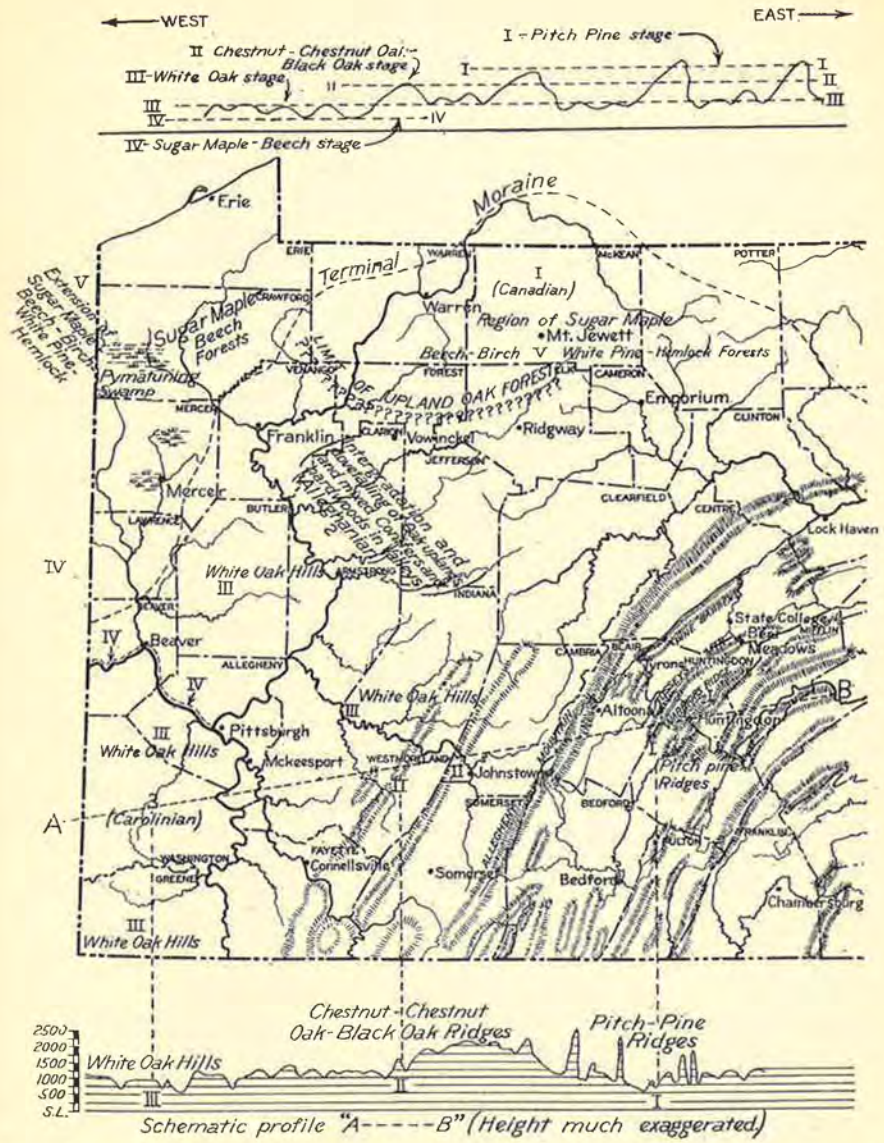
Nature is constantly working towards a leveling down of the continents, reducing the mountains, also filling the basins, to the end that

Bray, W. L. The development of the vegetation of New York State. N. Y. State College Forestry, Syracuse University, Technical Bull. 3: 166–7. 1915.

Harshberger, John W. Phytogeographic survey of North America. 1911. Die Vegetation der Erde. XIII. pp. 197–198.

Gleason, H. A. The structure of the maple-beech association in northern Michigan. Papers Mich. Acad. Sci., Arts & Letters. 4: Part I: 285–296. 1924.

PLATE I



Map of western Pennsylvania showing ecological plant geography and generalized diagram representing the major vegetational associations corresponding to physiographic stages, or equivalent soil stages, from the Huntingdon region west through the Pittsburgh region.

the surface is reduced to a low plain (peneplain) with slopes so gentle that the waters on their way to the oceans run too slowly to carry away more material than they deposit. The surface of such a peneplain would become covered with a uniform mantle of deep, fertile, moderately moist (mesophytic) soil, capable of supporting the most highly developed type of vegetation that the climate would permit (Nichol's "Regional Climax Association Type").[3] Nature is universally reducing rocks to soil by wearing and dissolving them and, as the rocks are changed to gravels, sands, or the finer clays and silts, the remains of animal and plant life are incorporated with the mineral materials and the result is a fertile water-retentive soil very favorable to the growth of vegetation. On the other hand, depressions, such as lakes, tend to become filled with sands, muds, and organic remains, the result of this process, also, being finally a level, moderately moist, fertile soil. In fact, Nature is everywhere working from dry (xerophytic) and from wet (hydrophytic) conditions towards a common moderately moist (mesophytic) condition, and it is of importance that this trend is, correspondingly, one from the least to the most suitable for the growth of vegetation.

As the conditions of the habitat become in this manner more suitable for vegetation there are corresponding changes in the groupings of its plant species, one plant society succeeding another, until, in the final mesophytic stage, stability will have been attained and the vegetation may be said to have reached the climax stage of the succession. In the latitude and general climatic region of Pennsylvania the writer believes that the climax stage of vegetation is the forest in which the sugar maple and beech are dominant, the beech being more partial to the finer-grained and more compact soils, the maple to the more gravelly or looser types, the two species being frequently intermingled.

Pennsylvania was derived geologically from a land mass to the east from which the sea was gradually filled farther and farther to the westward, until, in Permian times, the last marine waters disappeared. This last remnant of the sea was in the southwestern corner of the State. The strata thus deposited were compressed, folded, elevated, and, by Cretaceous time, this land had been generally well worn down to a peneplain (Schooley peneplain). Again elevated, this land, with the exception of our central mountain ridges, was again rather generally reduced (by Tertiary time) to a peneplain (Harrisburg peneplain). Another elevation of 100 to 150 feet was followed by the reduction of considerable

[3] Nichols, G. E. A working basis for the ecological classification of plant communities. Ecology 4: No. 1. 1923.

See, also: Clements, F. E. Plant succession, an analysis of the development of vegetation. Carnegie Institution, Publ. No. 242. 1916.

areas to practically peneplain level (mostly in the form of wide valley floors), this being known as the Worthington peneplain.[4] Up to the time of the Glacial Period there has been still further elevation and reduction of a minor degree.

After the formation, during Glacial times, of the Allegheny and Ohio rivers, probably associated also with subsequent elevation, the streams of western Pennsylvania began actively to cut down into the wide rounded valleys of pre-glacial times. The present even sky-line which marks, in general, the tops of the mountain ridges of central Pennsylvania, is formed by the remnants of the Cretaceous peneplain (Schooley), in places considerably more than 2,500 feet above the sea. Below this, and extensively indicated by the sky-line of the hills in the Pittsburgh district, is the Harrisburg (Tertiary) peneplain, considerable areas of it there being at an altitude of about 1,200–1,300 feet, while at about 1,100 feet altitude are the divides and terraces representing remnants of the Worthington peneplain. Still lower, in the western end of the State, along the larger streams, are remnants of old rounded valleys and level flood-plains of pre-glacial time, at an altitude of 900 feet or more, the Parker strath.[5] In this region the larger streams have cut down rapidly and the river at the junction of the Allegheny and Monongahela at Pittsburgh is now about 700 feet above sea-level.

As indicated by the above brief outline, southern Pennsylvania has had a rather complicated physiographic history during which more or less extensive lowlands with presumably deep and fertile soils were formed at various times, probably capable of supporting ecologically highly developed vegetation. The similarity of Tertiary floras to those now existing would leave little doubt that at least the Harrisburg and later peneplains did support a highly developed forest much like the forests of similar habitats at the present time. Portions of these old lowlands, although now at variously elevated levels, often still retain fairly deep and fertile soils and have a vegetation of well advanced or climax stages. Instances of this are some of the sugar maple groves of Somerset county, the sugar maple woods on the portions of elevated peneplain constituting the plateau in McKean County, and the sugar maple-beech groves on the pre-glacial valley floors in the Pittsburgh district.

As a result of the manner of their formation the rocks towards the east are successively older and have been for a longer time subjected to compression and folding than have the rocks towards the western border of the State. Also these rocks are, in general, likely to be harder and

[4] Butts, Charles. Kittanning Folio, Geol. Atlas U. S., U. S. G. S 115: 3. 1904.

[5] Munn, M. J. Sewickley Folio. Geol. Atlas U. S., U. S. G. S. Folio 176: 16–17. (Field Edit.) 1911.

more resistant to erosion. Although of approximately the same age, the anthracite of eastern Pennsylvania is harder than the bituminous coal of the Pittsburgh district. As one travels from Harrisburg to Pittsburgh it is a matter of common observation that the folding of the rock strata becomes rapidly less and less abrupt, being mere wavy folds, at the west, and the strata bent even beyond the vertical in places to the east. Sharply folded strata, with their broken and crumpled rocks, erode easily and quickly along the lines of such softer strata as they may include. For this reason, largely, the ridges towards Harrisburg consist mainly of the most resistant remnants of the large and sharp folds. On the other hand, towards Pittsburgh, the rocks are less folded and broken, and, even though mainly softer, and sooner covered with a mantle of soil, the gentleness of the folds has in part operated to prevent the disappearance of the soil. On Warriors Ridge or Tussey Mountain, for instance, the crest consists of large angular blocks of rock with only small pockets of soil on or between these rocks. Farther down the slope more soil has accumulated and this stage corresponds to the less eroded and more nearly soil-covered tops of some of the more rounded ridges to the west, such as Laurel Hill Mountain. Still farther down the slope or at the base of Tussey Mountain the rocks are completely covered with a mantle of soil, and this stage corresponds, roughly, to the soil conditions on the tops of the ridges and hills of slightly folded strata in the Pittsburgh district.

The forces of erosion may be expected eventually to reduce Tussey Mountain to a lower altitude with less abrupt slopes, and opportunity will be given for soil to accumulate to such an extent that it may then correspond to the present condition on the top of Laurel Hill Mountain. Still further reduction would bring this down to the stage of soil-covered hills such as now abound in the Pittsburgh district. After a very long period the Tussey Mountain region may be reduced more or less completely to a fairly level plain with deep, loose, fertile soils, and its condition would be similar to the present soils of the glaciated rolling lands

PLATE II

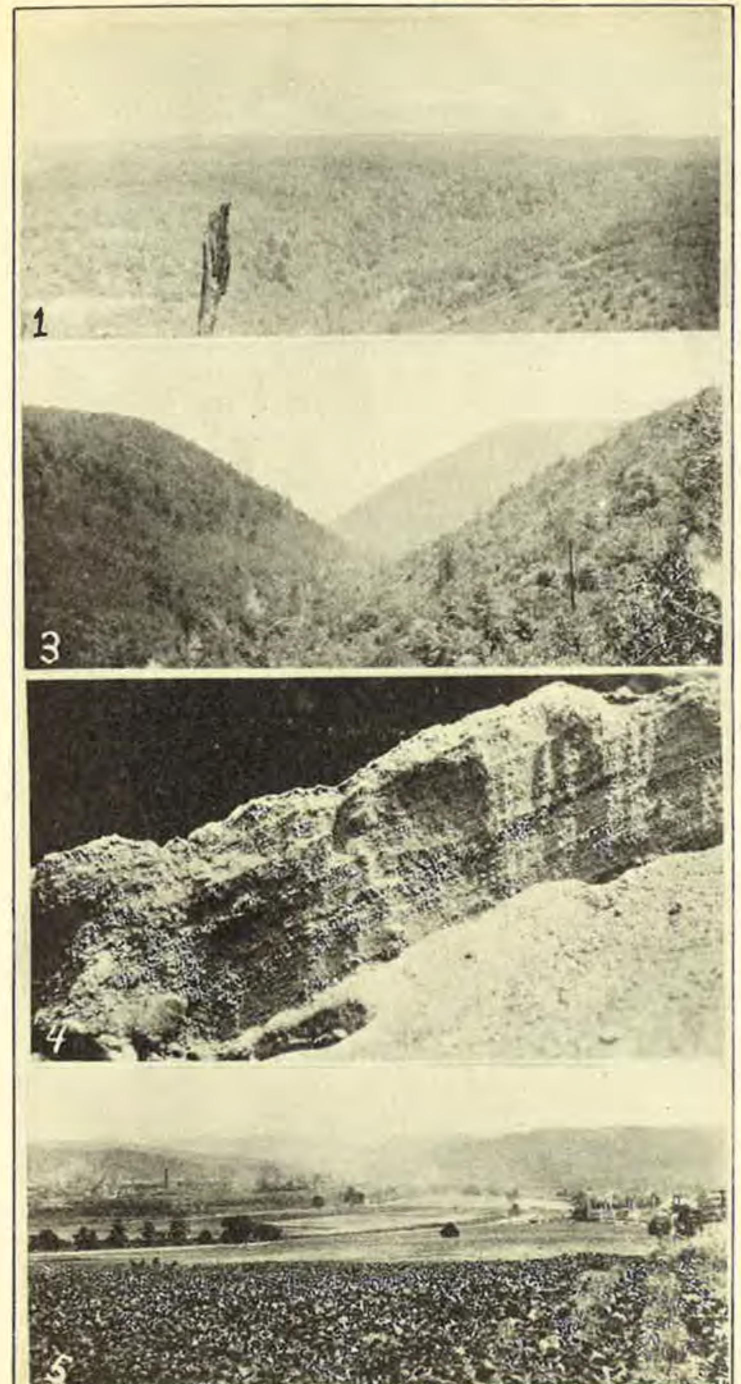
STAGES IN THE REDUCTION OF A PENEPLAIN, CENTRAL PENNSYLVANIA.

FIG. 1.—Looking northwest over plateau (Allegheny Mountains) from a short distance above Horseshoe Curve, P. R. R., west of Altoona. About 2,400 feet altitude. O. E. J., May 27, 1922.

FIG. 3.—From same place as Fig. 1, but looking in opposite direction (east) down Burgoon Gap and past Kittanning Point, Horseshoe Curve. O. E. J., May 27, 1922.

FIG. 4.—Deposit of sand and gravel laid down, as the result of a July thunderstorm, along flood-plain of Lynn Run, Laurel Hill Mountains, southeast of Rector, Pa. O. E. J., July 22, 1923.

FIG. 5.—Looking southeast from Warriors Ridge down the Juniata River and past Huntingdon towards Jacks Mountain. O. E. J., July 20, 1908.



of central Ohio or to the ecologically similar mesophytic flood-plain soils.

The water-holding power of the rocks on the top of such mountains as Warriors Ridge or Tussey Mountain is slight. With the reduction of these rocks to gravel or sand, the water-holding power rapidly increases. More or less thoroughly decayed plant material, such as humus in its various forms (duff, peat, etc.), has a remarkable power of absorbing and retaining water.[6] The plant humus that mixes with the mineral materials and becomes part of the soil of the lower slopes more particularly adds greatly to the ability of the soil to supply water and dissolved mineral salts for the needs of plants.

Putting the matter briefly, there is a series of plant habitats from the top of such a ridge as Tussey Mountain, down the slope, that are successively more favorable for plant life. Furthermore, this slope series of plant habitats is closely duplicated by a series of increasingly favorable habitats on the tops of the less and less sharply folded, and, from the standpoint of formation or retention of soils, more and more mature ridges, hills, and rolling uplands to the west. According to this idea, there is from east to west, from the Huntingdon region through the Pittsburgh region, a series of plant societies, beginning with the pitch pine forest association and ending with the climax sugar maple—beech forest association, the main organization of the vegetation being, in order of succession, as follows:

THE PITCH PINE—SUGAR MAPLE—BEECH RIDGE SUCCESSION

I

Pitch Pine Association[7]

Trees

Dominant: Pitch pine (*Pinus rigida*).[8]

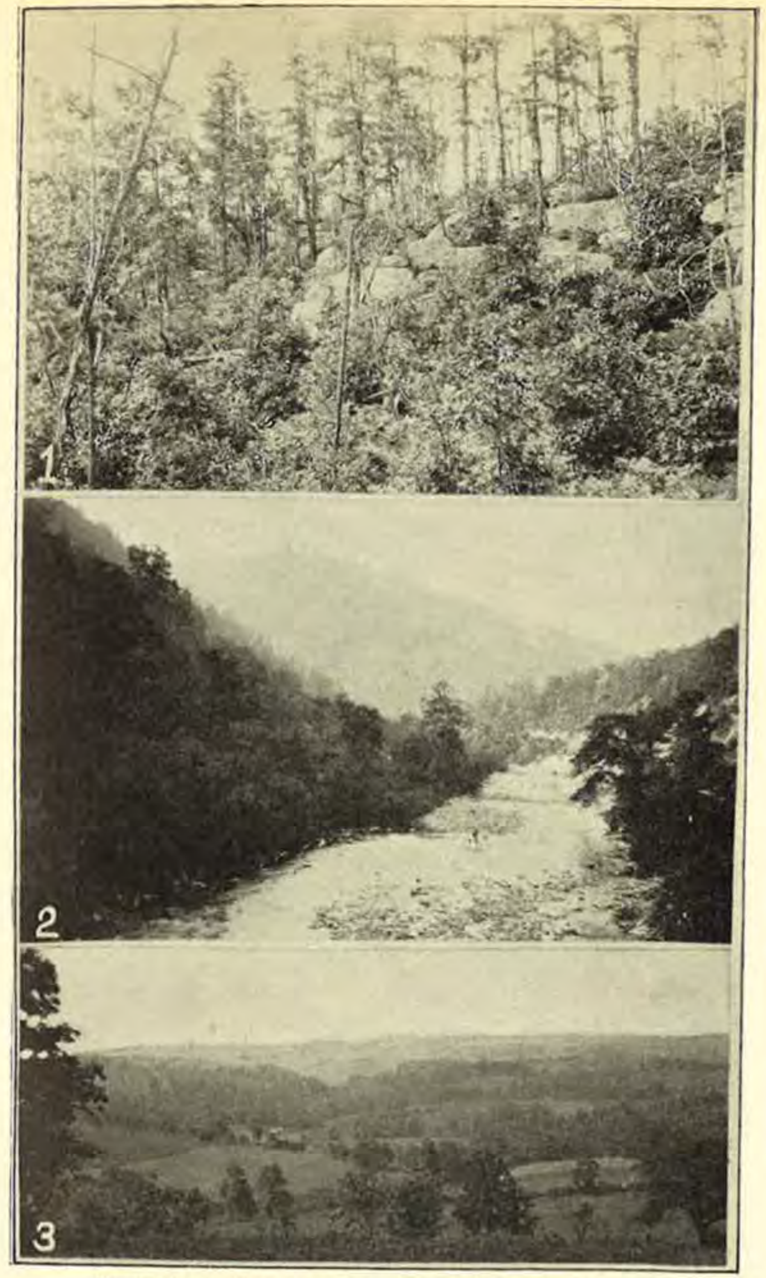
Secondary: Black oak (*Quercus velutina*).
Chestnut oak (*Q. Prinus*).
Chestnut (*Castanea dentata*).
Black birch (*Betula lenta*).
Big-toothed aspen (*Populus grandidentata*).

[6] Russell, E. J. Soil conditions and plant growth. 4th edit., 1921.

[7] Inasmuch as this is probably the most mesophytic forest vegetation possible under the prevailing edaphic (soil) factors this may be termed a "sub-climax" (Clements) or the "edaphic climax" association (Nichols).

[8] No attempt at systematic sequence has been attempted in the various lists of species other than to generally place the more important or abundant species first.

Plate III



Pitch Pine—Sugar Maple—Beech Ridge Succession, Central and Western Pennsylvania.

Fig. 1.—Pitch pine association, on top of Warriors Ridge, northwest of Huntingdon, Pa. O. E. J., July 20, 1908.

Fig. 2.—Chestnut—Chestnut oak—Black oak association. Looking up Indian Creek Valley from B. & O. R. R., Laurel Hill Mountains, northwest of Ohio Pyle. O. E. J., June 23, 1917.

SMALL TREES AND SHRUBS

Dominant: Scrub oak (*Quercus ilicifolia*).
Dwarf chestnut oak (*Q. prinoides*).
Smooth sumac (*Rhus glabra*).
Secondary: Mountain laurel (*Kalmia latifolia*).
New Jersey tea (*Ceanothus americanus*).

HERBS

Dominant: Bracken (*Pteridium latiusculum*).
Blueberry (*Vaccinium vacillans*).
Secondary: Low blueberry (*V. angustifolium*).
Bush clover (*Lespedeza capitata*).
Huckleberry (*Gaylussacia baccata*).
Sweet fern (*Comptonia peregrina*).

The above outline of the pitch pine association is from a survey of the top of Tussey Mountain, near Huntingdon, Pa., in August, 1910. As may be seen from fig. 1 of plate III the soil consists mostly of big blocks of rock with small pockets of finer materials between them, or on them, and at times this is a very dry (xerophytic) habitat. There is, quite evidently, not enough water available here to support a broad-leaved forest, such as oaks, with their much greater areas of water-transpiring leaf-surface. The total transpiring area here per unit of land occupied is evidently relatively small and it is to be noted, further, that there are but three well-marked layers or stories of vegetation, even though the foliage of the first story (pitch pines) intercepts very little of the light. In connection with the water-holding power of soils of various kinds and degrees of fineness it is of interest for this habitat to call attention also to the varying distances from which soils can raise water by capillarity. The soils which are mingled with the rocks on Tussey and similar ridges, as observed at a number of places, are relatively coarse, being stony, gravelly, sandy, and are probably unable to raise water by capillarity from more than a few inches below the surface, even should it be present in sufficient amounts.[9] It is quite probable that the scant and semi-xerophytic character of the vegetation here is in direct relation to a deficiency of water in the habitat.

II

CHESTNUT—CHESTNUT OAK—BLACK OAK ASSOCIATION

TREES

Dominant: Chestnut (*Castanea dentata*).
Chestnut oak (*Quercus Prinus*).
Black oak (*Q. velutina*).
Pitch pine (*Pinus rigida*).

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[9] Hilgard, E. W. Soils p. 201. 1906.

Secondary: Red maple (*Acer rubrum*).
Black birch (*Betula lenta*).
Sour gum (*Nyssa sylvatica*).
Tulip tree (*Liriodendron Tulipifera*).
Sassafras (*Sassafras Sassafras*).
White oak (*Quercus alba*).
Basswood (*Tilia americana*).

LOW TREES AND SHRUBS

Mountain laurel (*Kalmia latifolia*).
Mountain azalea (*Azalea periclymenoides = A. nudiflora*).
Blueberry (*Vaccinium vacillans*).
Deerberry (*Polycodium stamineum*).

LOW SHRUBS AND HERBS

Dominant: Trailing arbutus (*Epigaea repens*).
Wintergreen (*Gaultheria procumbens*).
Wild indigo (*Baptisia tinctoria*).
Bracken (*Pteridium latiusculum*).
Secondary: Moccasin flower (*Cypripedium acaule*).
Yellow lady'-slipper (*C. pubescens*).
Wild yam (*Dioscorea villosa*).
Panicled hawkweed (*Hieracium paniculatum*).
Rattlesnake weed (*H. venosum*).
Naked-flowered tick-trefoil (*Meibomia nudiflora*).
Hairy angelica (*Angelica villosa*).
Entire-leaved false foxglove (*Aureolaria laevigata*).
Silver rod (*Solidago bicolor*).
Big-leaved aster (*Aster macrophyllus*).
Wild sarsaparilla (*Aralia nudicaulis*).
Lousewort (*Pedicularis canadensis*).
Also a number of other less common species.

The above list represents the general type of vegetation on the uppermost slopes and undisturbed top of Chestnut Ridge, above Hillside, Westmoreland Co., Pa., many times explored by the Botanical Society of Western Pennsylvania. The soil is stony, with here and there large blocks of sandstone, but it mostly consists of a sandy-clay with numerous small stones. The pitch pines are not numerous, these probably to be regarded as relicts of stage I, although they may be actually members of stage II also. This stage is characteristic of most of the slopes and top of Laurel Hill Mountains also.[10] Figure 2, plate III.

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[10] This is essentially the type of vegetation termed by Shreve, Forrest, the "Ridge Type of Forest," in Plant Life of Maryland. Special Publication Md. Weather Bur., 3: 282–284. 1910.

III

White Oak Association

Trees

Dominant: White oak (*Quercus alba*).
Secondary: Shagbark hickory (*Hicoria ovata*).
Red maple (*Acer rubrum*).
Shingle oak (*Quercus imbricaria*).
Scarlet oak (*Q. coccinea*).
Chestnut oak (*Q. Prinus*).
Black oak (*Q. velutina*).
Red oak (*Q. rubra*).
Chestnut (*Castanea dentata*).
Wild black cherry (*Prunus serotina*).

Small Trees and Shrubs

Flowering dogwood (*Cornus florida*).
Ironwood (*Ostrya virginiana*).
Mountain laurel (*Kalmia latifolia*).
Juneberry (*Amelanchier canadensis*).
Redbud (*Cercis canadensis*).

Low Shrubs

Trailing arbutus (*Epigaea repens*).
Blueberry (*Vaccinium vacillans*).
Huckleberry (*Gaylussacia baccata*).
New Jersey tea (*Ceanothus americanus*).
High-bush blackberry (*Rubus allegheniensis*).
Wild gooseberry (*Ribes Cynosbati*).

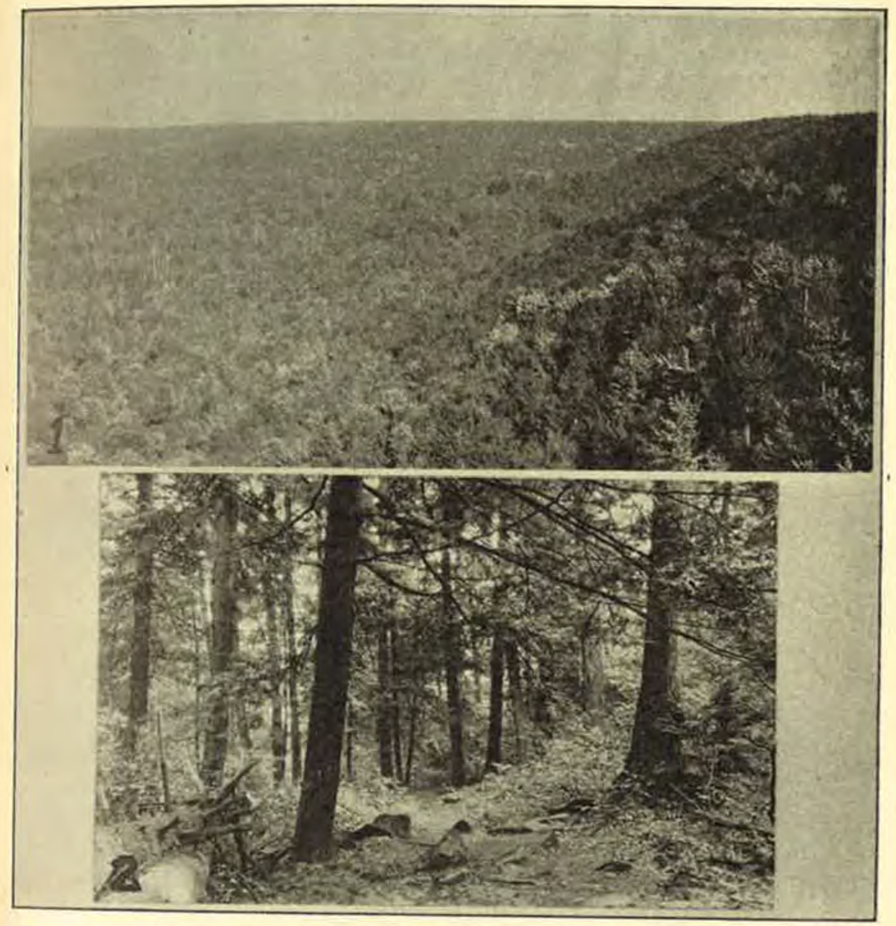
Woody Vines

Virginia creeper (*Psedera quinquefolia*).
Poison ivy (*Rhus radicans*).
Greenbrier (*Smilax hispida*).

Herbs

Black snakeroot (*Cimicifuga racemosa*).
Naked-flowered tick-trefoil (*Meibomia nudiflora*).
Asters (*Aster undulatus, macrophyllus, cordifolius*).
Goldenrods (*Solidago bicolor, nemoralis,* and *ulmifolia*).
Ground-pine (*Lycopodium obscurum*).
Pipsissewa (*Chimaphila umbellata*).
Shin-leaf (*Pyrola elliptica*).
Wintergreen (*Gaultheria procumbens*).
Rattlesnake weed (*Hieracium venosum*).
Rue anemone (*Syndesmon thalictroides*).
Early saxifrage (*Saxifraga virginiensis*).
Wood-rush (*Juncoides intermedium*).
Curly grass (*Danthonia spicata*).

Plate IV



Sugar Maple—Beech—Birch—White Pine—Hemlock Association, North-central Pennsylvania.

Fig. 1.—Looking north across the plateau (Harrisburg peneplain) from near Mt. Jewett, Pa. O. E. J., September 5, 1922.

Fig. 2.—Hemlock consociation of upper slope at Clarion, Pa. O. E. J., September, 1921.

THALLOPHYTES AND BRYOPHITES[11]

Pincushion moss (*Leucobryum albidum*).
Pigeonwheat moss (*Polytrichum ohioense*).
Anomodon rostratus.
Cladonia lichens, various species.
Russula emetica.
Poison amanita (*Amanita phalloides*).
Lactarius spp.

This is about the usual composition of the upland forest vegetation of the rolling uplands or rounded hills comprising the remnants of the Harisburg peneplain in southwestern Pennsylvania, at altitudes of 1,200–1,300 feet above the sea. It is the same association as that termed the "Slope Forest" by Shreve in western Maryland[12] and is in part the "Zone of Dominance of Oaks, Hickories, Chestnut, Tulip-tree, etc.," described by Bray for low altitudes up to 1,200 feet in southern New York.[13] In Pennsylvania it occurs through the southern half of the State on the soil-covered lower slopes of the ridges and on the rolling hills of the mountain valleys, or even sometimes covering the valley floors. Northwards, in the central part of the State, as in Centre County, this forest vegetation begins to mix quite noticeably with the white pine and other species of the northeastern evergreen-deciduous transition forest[14] (white pine, hemlock, sugar maple, beech, etc.). Figure 3, plate III.

IV

SUGAR MAPLE—BEECH CLIMAX ASSOCIATION

This forest vegetation occupies in one form or another the best types of fertile, moderately moist soils. It occurs on some of the now-elevated remnants of the old soil-covered peneplains, such as the Harrisburg, in the Somerset and Ligonier valleys and, more particularly, the region to the west of Chestnut Ridge. It occurs in mountain coves where a deep, rich soil has accumulated; it is the characteristic forest vegetation on many of the preglacial valley floors of southwestern Pennsylvania, also

11 For a list of twelve mosses of this association, see: Jennings, O. E. Systematic and ecological notes on the mosses of western Pennsylvania. Bryologist, 18: 83–93. 1915.

12 *Op. cit.* pp. 275–282.

13 Bray, W. L. *Op. cit.* pp. 71–73.

14 Shreve, Forest. Vegetation areas of the United States. Geogr. Rev. 3: No. 2: Plate III. 1917. And text.

This is also the Alleghanian area (eastern humid transition) of Merriam, C. Hart. U. S. Dept. Agr., Biol. Surv. Bull. No. 10. 1898.

on many of the more recently-formed flood-plains; and, to the northwest and west, over into Ohio, it commonly occurs on the level or rolling lands of mixed glacial soils. It must be regarded as the climax forest in such places and it will not be replaced by another type of vegetation unless destroyed or disturbed by fire, lumbering, rejuvenated erosion cycles, or some other unusually highly modifying or destructive influence. This forest must be thought of as occupying the type of soil towards which the usual natural processes of erosion and peneplanation are tending and is the end result of vegetational successions in our climate on moderately moist fertile soils, no matter whether the succession begins with the rocky crest of a ridge in the mountains (xerarch) or whether it begins with the submerged vegetation of a lake or pond (hydrarch). The usual organization of this vegetation in western Pennsylvania is as follows:

TREES

Dominant: Sugar maple (*Acer saccharum*).
Beech (*Fagus grandifolia*).
Secondary: Pignut hickory (*Hicoria glabra*).
Shagbark hickory (*H. ovata*).
Mockernut hickory (*H. tomentosa* = *Carya alba* K. Koch).
Red oak (*Quercus rubra*).
White oak (*Q. alba*).
Red maple (*Acer rubrum*).
White ash (*Fraxinus americana*).
Basswood (*Tilia americana*).
White elm (*Ulmus americana*).
Black walnut (*Juglans nigra*).
Wild black cherry (*Prunus serotina*).
Honey-locust (*Gleditsia triacanthos*).
Tulip tree (*Liriodendron Tulipifera*).
A considerable number of other less common trees.

SMALL TREES

Wild plum (*Prunus americana*).
Ironwood (*Ostrya virginiana*).
Water beech (*Carpinus caroliniana*) in moisture spots.
Dotted hawthorn (*Crataegus punctata*).
Papaw (*Asimina triloba*).

SHRUBS

Maple-leaved viburnum (*Viburnum acerifolium*).
Gooseberry (*Ribes Cynosbati*).
Spicebush (*Benzoin aestivale*).
Elderberry (*Sambucus canadensis*).
High-bush blackberry (*Rubus allegheniensis*).
Black raspberry (*Rubus occidentalis*).

Herbs

Trout lily (*Erythronium americanum*).
Toothwort (*Dentaria laciniata*).
White dogbane (*Actaea alba*).
Mayapple (*Podophyllum peltatum*).
Ginseng (*Panax quinquefolia*).
Indian turnip (*Arisaema triphyllum*).
Blue cohosh (*Caulophyllum thalictroides*).
Wild spikenard (*Aralia racemosa*).
Bloodroot (*Sanguinaria canadensis*).
Ill-scented trillium (*Trillium erectum*).
Large-flowered trillium (*T. grandiflorum*).
Wild phlox (*Phlox divaricata*).
Spring beauty (*Claytonia virginica*).
Early saxifrage (*Saxifraga virginiensis*).
Greek-valerian (*Polemonium reptans*).
Waterleaf (*Hydrophyllum* spp.).
Honeywort (*Deringa canadensis*).
Beechdrops (*Leptamnium virginianum*).
Hairy sweet cicely (*Washingtonia Claytoni*).
Enchanter's nightshade (*Circaea latifolia*).
Numerous other, mostly less common, species.

Woody Vines

Summer grape (*Vitis aestivalis*).
Virginia creeper (*Psedera quinquefolia*).
Poison ivy (*Rhus radicans*).
Greenbriers (*Smilax hispida* and *S. rotundifolia*).

The time intervals between the great peneplanation cycles mentioned (Schooley, Harrisburg, and Worthington) were very great and on the great folds, such as Laurel Hill Mountain, the elevation, slope, exposure, and other factors have brought about less suitable ecological conditions than would have been the case had the peneplain remained at its original more or less approximate base-level. It appears that the habitat has now

PLATE V

The Hemlock Ravine Succession, Southwestern Pennsylvania.

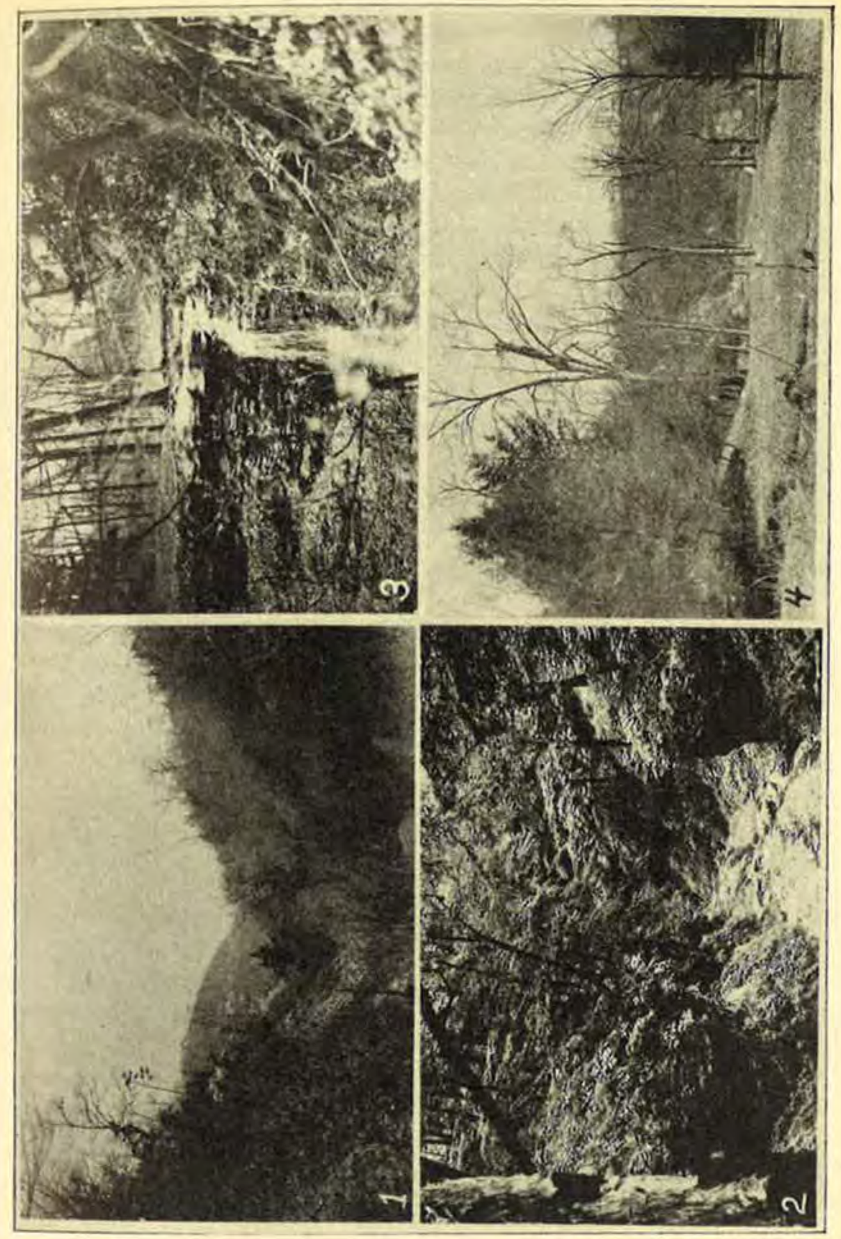
Fig. 1.—Looking up Falls Run ravine, Glenshaw, Pa. *Amelanchier canadensis* in bloom; hemlock at base of slope. O. E. J., April 25, 1915.

Fig. 2.—Hemlock ravine, just below Washboard Falls, Guyasuta Hollow, Sharpsburg, Pa. Hemlock consociation. O. E. J., June 18, 1908.

Fig. 3.—Sugar Maple—Beech association on old pre-glacial flood-plain immediately above the falls, Falls Run, Glenshaw, Pa. Hemlocks largely occupy the gorge into which the stream pitches. O. E. J., April 25, 1915.

Fig. 4.—Wildwood Ravine, about 10 miles north of Pittsburgh, Pa. The Hemlock—Birch—White Pine association on the slopes is met on the flood-plain by The Sugar Maple—Beech association. O. E. J., April 13, 1924.

Plate V



become adjusted to some stage which would be represented in the course of the reduction of a more sharply folded ridge, such as the Tussey or Warriors Mountain ridges. Farther west, the low folds, such as those in the Pittsburgh district, are now scarcely discernible among the hills and rolling uplands, and this is ecologically equivalent to a still more advanced stage in the reduction of such a mountain ridge.

From this standpoint we may represent the major vegetational associations of southern Pennsylvania, from the region of Huntingdon west through the Pittsburgh region, essentially as shown on Plate I, page 25, taking into consideration only the main sky-line contours.

Minor Successions

Having considered the general outline of the organization of the vegetation along the east-west transect from Huntingdon through Pittsburgh, there should be mentioned also, the minor details of the relations of the vegetational associations to the wearing down of the mountains. The slopes of the mountains are not uniform, as figured in the conventional diagram, but are cut in various ways by valleys, ravines, etc., which are generally in a state of active erosion and the vegetation is, correspondingly, just as actively changing, to end finally in the climax forest vegetation as soon as the land has been brought down to a lower level and, at least temporarily, has been laid out as a deep, fertile, moderately moist soil, such as the ordinary well established flood-plain. Everywhere in our mountains this process of building soils at lower levels is going on and their occupation by the climax forest vegetation can be seen. Every actively eroding trout stream, with its bordering hemlock—birch—rhododendron association is in one of the early stages of the series destined to end finally in the climax sugar maple—beech forest. Without discussing further what might appropriately be called the "Trout Stream Succession," there may be described in a general way the hemlock ravine succession near Pittsburgh, this being one of the various other minor successions involved in the general program ending in the climax forest.

The Hemlock Ravine Succession

With the damming of the northward flowing streams in western Pennsylvania during the Glacial Period, and the rearrangement of their drainages into the present Ohio River system, the larger streams were, to some extent, filled by glacial material but were, also, actively rejuvenated and have since cut down about 200 feet below their preglacial level. In a certain sense this has left the tributary streams hanging high above their outlets and they have been rapidly readjusting themselves by cutting down their valleys to approximately the new level of the trunk stream, this cutting beginning at the mouth of the tributary and working rapidly back, usually following the bottom of the old preglacial valley. Most of the smaller streams in the Pittsburgh district (the so-called "runs") have now had sufficient time to widen their valleys at the mouth and usually have even formed some flood-plain. Upstream from this the valleys usually contract rapidly into a ravine or gorge and at the head of this usually there are rapids or falls, where the rather slowly meandering stream in the old rounded preglacial valley above suddenly plunges down into the new valley below. Immediately above the falls or rapids, where undisturbed by man, there are still to be seen, patches of the climax sugar maple—beech forest which formerly occupied the rich flood-plains of the old preglacial valleys. The deep, cool, moist gorge or "hollow" into which the stream plunges is occupied by the hemlock association (perhaps more properly the hemlock consociation of the hemlock—birch—white pine association) which constitutes the first forest stage in this ravine series.[14] Briefly stated, the main organization of this vegetation is as follows:

I

Hemlock Association

Dominant:	Hemlock (*Tsuga canadensis*).
Secondary:	Red maple (*Acer rubrum*).
	Black birch (*Betula lenta*).
	Downy shadbush (*Amelanchier canadensis*).
	Rhododendron (*Rhododendron maximum*).

Where this association is best developed, as in the deeper gorges or up close to the falls, no other tree occurs with the hemlock (the hemlock consocies) and it usually wanders up over the edge of the falls or walls of the ravine, often spreading around to some little distance, probably this being associated with the extension of cool moist air up out of the hollow. In the course of time, the ravine, working upstream, will be accompanied by the hemlock forest until the stage of erosion will be reached where there can no longer be a deep, cool, moist hollow and then, with the widening of the upper part of the valley, the hemlock forest will disappear from it.

Other than the hemlock the plants of this association are chiefly spore plants of various kinds, among which the following are most prominent:

[14] Jennings, O. E. A note on the ecological formations of Pittsburgh and vicinity. Science, N. S., 27: 828–830. May 22, 1908.

Cladophora sp. (Alga); *Conocephalum conicum* (Hepatic); *Philonotis Muhlenbergii* (Moss).[15]

II

BIRCH—MAPLE—BEECH—OAK MIXED ASSOCIATION

A short distance below the head of the ravine the slopes recede and, where the widening has progressed so that the slopes are at an angle of about 30 to 45 degrees from the vertical, a mixed forest of rather difficult ecological classification appears. The hemlock gradually and almost entirely disappears and the trees are mainly deciduous. The soil is of a colluvial type, its constituent clay, sand, rock fragments, humus, etc., having been variously mixed up as it has been formed and has worked its way down the steep slopes. It is generally loose and in spots fairly deep, its characteristics varying considerably from spot to spot, owing to the miscellaneous ways in which it has been formed. In some respects it might be said to represent a kind of crazy-quilt pattern of small areas of soils characteristic of several different ecological habitats. Perhaps partly for this reason and partly because of the protection afforded in the narrow valley against the cold winds, these slopes have the richest flora of early blooming plants ("spring flowers"), mostly biennials or perennials, to be found in the whole region. Where undisturbed, the characteristic organization of this vegetation is about as follows, only the more important species being listed:

TREES

Black birch (*Betula lenta*).
Red maple (*Acer rubrum*).
Beech (*Fagus grandifolia*).
Black oak (*Quercus velutina*).
Red oak (*Q. rubra*).
Basswood (*Tilia americana*).
White ash (*Fraxinus americana*).

SHRUBS

Flowering dogwood (*Cornus florida*).
Redbud (*Cercis canadensis*) evidently near limestone.
Downy shadbush (*Amelanchier canadensis*).

HERBACEOUS PLANTS

A large number of "spring flowers" are characteristic of these fairly rich and usually sheltered slopes. One of the most prominent seasonal aspects may well be

[15] Jennings, O. E. Systematic and ecological notes on the mosses of western Pennsylvania. Bryologist 18: 83–93. November, 1915. Thirteen species of mosses are listed as occurring rather characteristically in this association.

called the *Trillium grandiflorum* Aspect, when, from a distance the whole slope appears white, the Trilliums outshining by far the numerous accompanying spring-blooming plants.

Later in the spring the sweet cicely aspect is in places prominent, and one of the characteristic early summer herbs is the honewort (*Deringa canadensis*). In July the black-snakeroot (*Cimicifuga racemosa*) determines an aspect and among the later-flowering plants may be mentioned particularly tick-trefoil (*Meibomia Dillenii*), white-snakeroot (*Eupatorium urticaefolium*), tall wood-lettuce (*Nabalus altissimus*), and the blue-stem goldenrod (*Solidago caesia*). Many other less common species are often locally prominent.

III

BLACK OAK—RED OAK—SCARLET OAK ASSOCIATION

Not many of the tributary streams in the Pittsburgh region are yet far enough along in their rejuvenated cycle to have reduced the slopes at their outlet to a much lower angle than included in the stage just described, but there appears to be some indication that the black oak forest is characteristic of such a habitat. The same forest is characteristic of the preglacial hillside slopes leading up to the white oak forest vegetation on the uppermost slopes and tops of the hills. In the same manner that the black oak forest of these slopes will be replaced by the white oak forest, when the hills become further reduced, it can be expected that the reduction of the slopes at the mouth of the tributary streams will, also, result in occupancy by the white oak forest.

IV

SYCAMORE—WILLOW ASSOCIATION

Not until the hemlock ravine has begun to widen considerably will alluvial material begin to accumulate along the stream, building up a flood-plain. Along larger streams there soon appears the sycamore—willow association, but on the young flood-plain of the hemlock ravine this is often absent and the first trees to appear are the white elm. Along the larger streams of the Susquehanna drainage system, but not along the streams finding their way westward, the red birch (*Betula nigra*) is a prominent member of this association.

V

WHITE ELM—SILVER MAPLE ASSOCIATION

In the narrow ravines the silver maple rarely appears and the association is there represented by the white elm consociation. On the wet flood-plain lands along the larger streams of central and western Pennsylvania this association includes a considerable variety of trees, among which the generally more prominent ones are the red maple, tulip tree, black walnut, shagbark and bitternut hickories, red oak, swamp white oak, and white ash, along with older specimens of sycamore and young or scattering trees of the sugar maple, in addition to the white elm and silver maple.

VI

SUGAR MAPLE—BEECH ASSOCIATION

Towards the mouth of the ravine and along the banks of the larger streams the alluvial flood-plain is eventually built up to a height above ordinary floods and becomes occupied by the climax sugar maple—beech forest.

Along the slopes of a hemlock ravine there are frequent land-slides which expose new areas for occupancy by plants and so initiate a new succession. Prominent stages in this succession are (a) the red elder—wild hydrangea thicket association, and farther along in the succession, (b) the beech consocies of the sugar maple—beech forest. This series is abundantly displayed in its various stages along the larger streams where undercutting has resulted in extensive landslides and talus slopes.

Plate V illustrates diagrammatically the hemlock ravine succession and this may be considered as one of the minor or subsidiary elements in the whole generalized succession beginning with the pitch pine association and ending in the climax sugar maple—beech association.

SAND-BAR—FLOOD-PLAIN SUCCESSION

Another succession of considerable importance along the larger streams already mentioned in connection with the upbuilding of the alluvial flood-plain is the sand-bar—flood-plain succession. Where the current is not too swift, gravel and sand frequently form shallows and at such places the water-willow (*Dianthera americana*) frequently becomes established in beds. Because of its ability to slow down the current and to sift out the floating debris it is frequently able to build up the bottom to such a level that the sycamore (*Platanus occidentalis*) and the willows (*Salix fragilis* and *S. interior*) in turn are able to establish themselves. Along the lower Juniata and the Susquehanna the red birch (*Betula nigra*) also appears. Early arrivals of interest in this forest are, usually, a wealth of woody vines: Poison ivy (*Rhus radicans*), river grape (*Vitis vulpina*), and the Virginia creeper (*Psedera quinquefolia*), as well as the herbaceous vines, *Sicyos* and *Echinocystis* and, frequently, *Polygonum* and *Clematis*.

This forest vegetation assists materially in building up the soil, both by its own deposits of organic material and by slowing down the current during floods and causing a greater deposition of mud and sand. It is finally succeeded by the silver maple—white elm association and this is, in time, succeeded by the climax sugar maple—beech forest.

OX-BOW POND SUCCESSION

Another succession of interest but occupying only small areas in southern Pennsylvania is the ox-bow pond succession. Such ponds are being drained or filled to such an extent that but few remain in anything like their natural condition. From such studies as have been made, the following stages are indicated:

I

SMALL OX-BOW POND

Where small and subject to but little wave action, and also shaded by surrounding trees, there is usually considerable algal growth of Spirogyra, Vaucheria, Oedogonium, and also the duckweed (*Spirodela polyrhiza*).

LARGER OX-BOW POND

When a larger ox-bow pond is formed, the following plants appear to be at once characteristic: Pondweed (*Potamogeton natans*), waterweed (*Philotria canadensis*); and, less abundantly, Vallisneria, Ceratophyllum, Myriophyllum, and Utricularia.

II

In an old and well-established pond, such as Logan's Ferry Pond was a few years ago, the following vegetational organization was found, the various plant societies mentioned being in the nature of zones and proceeding from the deeper water (A) to the shore thicket (D):

A

CASTALIA—NYMPHAEA ASSOCIES

Dominant:	Spatterdock (*Nymphaea advena*).
	Arrow-leaf (*Sagittaria latifolia*).
	Duckweed (*Spirodela polyrhiza*).
Secondary:	White water lily (*Castalia odorata*).
	Water plantain (*Alisma subcordatum*).
	Smaller duckweed (*Lemna minor*).
	Floating hepatics (*Riccia natans* and *fluitans*).
	Algae: Spirogyra, Oedogonium and Pandorina.

B

TYPHA—SAURURUS ASSOCIES

Dominant: Cat-tail (*Typha latifolia*).
Lizard-tail (*Saururus cernuus*).
Secondary: Blue flag (*Iris versicolor*).
Bulrush (*Scirpus lacustris*).
Duckweed (*Spirodela polyrhiza*).
Hepatic (*Riccia natans*).

C

ONOCLEA—POLYGONUM ASSOCIES

Dominant: Sensitive fern (*Onoclea sensibilis*).
Tear-thumb (*Polygonum sagittatum*).
Secondary: Lizard-tail (*Saururus cernus*).
Wool-grass (*Scirpus cyperinus*).
Marsh fern (*Dryopteris Thelypteris*).
Swamp milkweed (*Asclepias incarnata*).
Bottle gentian (*Gentiana Andrewsii*).
Wood nettle (*Boehmeria cylindrica*).
Purple-stem aster (*Aster puniceus*).
Crooked-stem aster (*Aster prenanthoides*).
False goldenrod (*Solidago graminifolia*).
Spike-rush (*Eleocharis acicularis*).
Cow parsnip (*Heracleum lanatum*).
Sedges (*Carex* spp.).

D

CEPHALANTHUS—ROSA ASSOCIES

Dominant: Button-bush (*Cephalanthus occidentalis*).
Swamp rose (*Rosa carolina*).
Secondary: Cordate-leaved willow (*Salix cordata*).
Black willow (*Salix nigra*).
Black elderberry (*Sambucus canadensis*).
River-bank grape (*Vitis vulpina*).
Bindweed (*Polygonum Convolvulus*).
Swamp dogwood (*Cornus Amomum*).

The thickets of the Cephalanthus—Rosa Associes are invaded by the red maple and white elm, and the appearance of these species in the habitat indicates that the vegetation at that point merges into the flood-plain forest vegetation, and that this would eventually pass into the climax sugar maple—beech forest.

NORTHERN CENTRAL PENNSYLVANIA

In the northern part of Pennsylvania, from Lycoming and Tioga counties westward, two geological features are important in a scheme for

the classification of the vegetation. First, there occurred, subsequently to the formation of the Harrisburg peneplain, an upward doming of the earth's crust, so that the peneplain stands at an elevation of 2400–2500 feet above the sea in McKean and Tioga counties, as compared with its elevation of about 1200–1300 feet in the Pittsburgh district. It is noteworthy that on the domed part of the peneplain there still remain considerable areas that have not yet been to any considerable extent dissected or reduced. The second important feature to be noted is that only the northwestern third of this area was glaciated.

With the retreat of the ice at the end of the Glacial Period it may be assumed that the north-central portion (the domed part of the Allegheny Plateau) probably passed through the tundra stage and then a stage of boreal coniferous forest and that it is now in a transition stage, with here and there remnants of what Bray calls the Canadian Transition Zone in New York State (his zone "D"), as evidenced by rather rare occurrences of mountain ash (*Sorbus americana*), hobblebush (*Viburnum alnifolium*), shining clubmoss (*Lycopodium lucidulum*), yew (*Taxus canadensis*), paper birch (*Betula papyrifera*), mountain aster (*Aster acuminatus*), and others.[16] Among the rare and scattering relicts of the migrating northern flora in various parts of the northern half of the State, there may be mentioned the following: Red pine (*Pinus resinosa*), rare in the northern central part of the State;[17] black spruce (*Picea Mariana*), rare in upland swamps and cool valleys in Huntingdon, Centre, Clinton, Lycoming, and perhaps Cambria counties, in the mountains of central Pennsylvania; and balsam-fir (*Abies balsamea*), rare in cold swamps in Centre, Clinton, Lycoming and McKean counties.

For the most part, however, the climax flora of the old peneplain (Harrisburg) is what Bray has called the Allegheny-Transition Zone (his zone "C"). On the plateau around Coudersport (Potter County), and Mt. Jewett and Kane (McKean County), the characteristic vegetation is generally as follows:

SUGAR MAPLE—BEECH—BIRCH—WHITE PINE—HEMLOCK ASSOCIATION

TREES

Dominant: Sugar maple (*Acer saccharum*).
Beech (*Fagus grandifolia*).
Yellow birch (*Betula lutea*).
White pine (*Pinus Strobus*).
Hemlock (*Tsuga canadensis*).

[16] Bray, Wm. L. The development of the vegetation of New York State. N. Y. State College Forestry, Syracuse Univ., Technical Publ. 3: 1–186. Nov., 1915.

[17] Illick, Joseph. Pennsylvania Trees, Penn. Dept. Forestry, Bull. 11, 4th edit., p. 78. 1923.

Secondary: Black birch (*Betula lenta*).
Paper birch (*B. papyrifera*).
Red maple (*Acer rubrum*).
Trembling aspen (*Populus tremuloides*).
Pin cherry (*Prunus pennsylvanica*).
Chestnut (*Castanea dentata*).
White ash (*Fraxinus americana*).
Cucumber tree (*Magnolia acuminata*).
Tulip tree (*Liriodendron Tulipifera*).
Wild black cherry (*Prunus serotina*).
Big-tooth aspen (*Populus grandidentata*).

Shrubs and Small Trees

Maple-leaved arrow-wood (*Viburnum acerifolium*).
Hobble-bush (*V. alnifolium*).
Staghorn sumach (*Rhus typhina*).
Bush honeysuckle (*Diervilla Diervilla*).
High-bush blackberry (*Rubus allegheniensis*).
Canada blackberry (*Rubus canadensis*).
Prairie willow (*Salix humilis*).
Hercules' club (*Aralia spinosa*).
Red raspberry (*Rubus strigosus*).

Herbs

Bracken (*Pteridium latiusculum*).
Club moss (*Lycopodium annotinum, L. complanatum, L. lucidulum,* and *L. clavatum*).
Hay-scented fern (*Dennstedtia punctilobula*).
Marginal shield-fern (*Dryopteris marginalis*).
Asters (*Aster macrophyllus, A. divaricatus,* and *A. acuminatus*).
Goldenrods (*Solidago juncea* and *S. rugosa*).
Pearly-everlasting (*Anaphalis margaritacea*).
New York fern (*Dryopteris noveboracensis*).
Ill-scented trillium (*Trillium erectum*).
Red baneberry (*Actaea rubra*).

In places along the valleys and at lower altitudes there are coming into this region some of the plants of the more southern deciduous forest,[18] such as the red oak (*Quercus rubra*). This has been noted by the

[18] Shreve, Forrest. Vegetation Areas of the United States. Geogr. Rev., Vol. III, No. 2, Pl. III and text. 1917.

PLATE VI

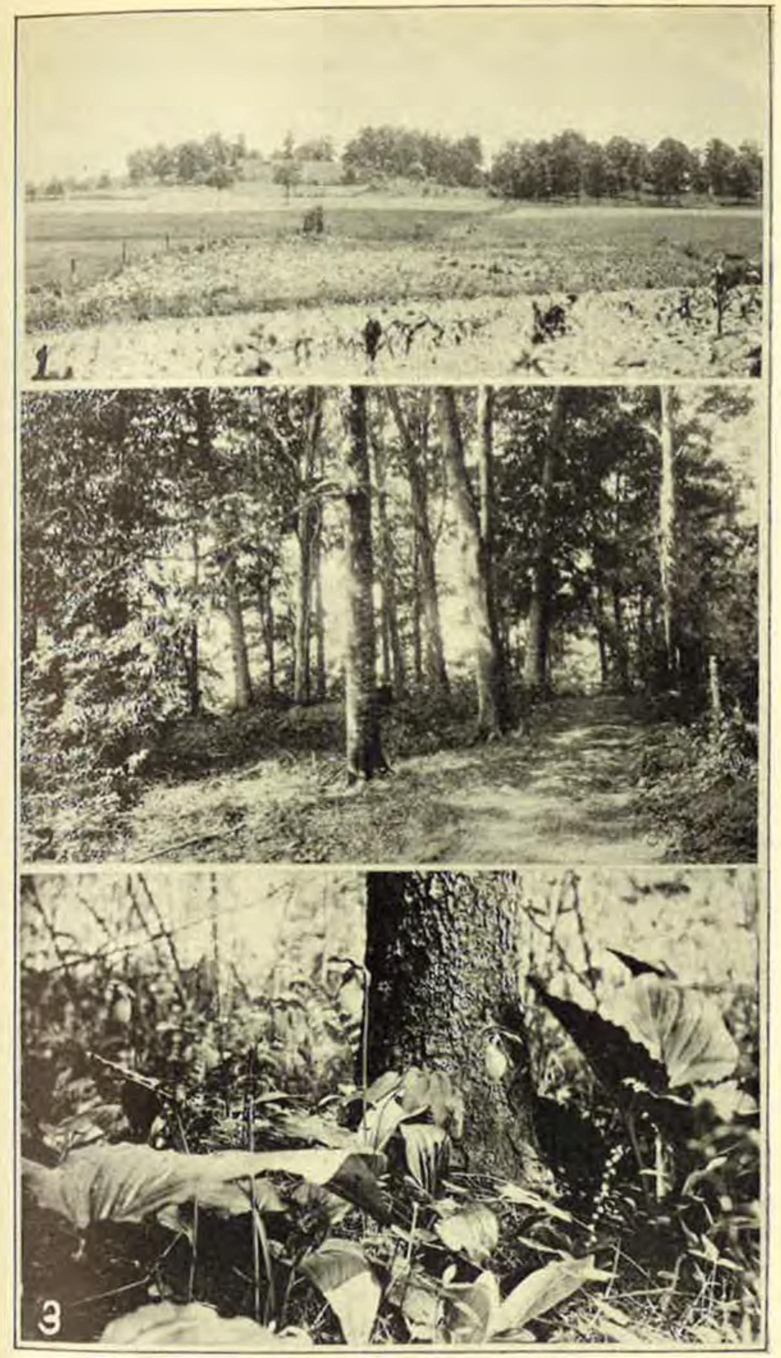
Glaciated Region of Northwestern Pennsylvania

Fig. 1.—Sugar Maple Consociation, on glacial moraine, two miles northeast of Hartstown, Crawford Co., Pa. O. E. J., June 11, 1922.

Fig. 2.—Beech Consociation, on low moraine along the southwestern edge of Pymatuning Swamp, one mile northwest of Hartstown, Pa. O. E. J., June 20, 1923.

Fig. 3.—Sphagnum—Tamarack Bog, near Hartstown, Pa. *Cypripedium acaule,* skunk cabbage, Tiarella, *Saxifraga pennsylvanica,* etc. O. E. J., June 1, 1919.

Plate VI



writer at Ulysses, Potter County, and in the valley just south of Kane, McKean County. As one goes north from Butler to Kane along the B. & O. R. R., the oaks, with the exception noted, seem to disappear from the general landscape in the neighborhood of Vowinckel, in the northeastern corner of Clarion County. It appears that the deciduous forest is invading this plateau region in the form of finger-like projections up the sheltered valleys.

Northwestern Pennsylvania (Glaciated)

The northwestern corner of Pennsylvania, as indicated on the map (Plate I, page 25), was rather thoroughly worked over by the glaciers, probably more than once, and the deep deposits of glacial material for the most part constitute an excellent series of soils for plant growth. In fact, these soils, as prepared by the glaciers, were likely so good as to be occupied relatively quickly by the best type of vegetation possible in the prevailing climate, in other words, the climax vegetation, provided that the topography and conditions of drainage were suitable for such vegetation. In a few places, as, for instance, northeast of Hartstown, the morainal ridges may be too steep and sharp to support the sugar maple—beech association. In other places, as, for instance, in many of the wide valleys and glacial depressions, drainage is poor and various stages may be seen ranging from the black ash—red maple swamp association through the white elm lowland association to the climax sugar maple—beech association. Here, as also through northern Ohio, there is a clear distinction between the two consociations in the climax forest. On the morainal and other glacial knolls and ridges, and in fact on almost any well-drained soil of a mixed morainal character, the sugar maple consociation prevails. On the generally more nearly level areas of fine-grained clayey soils, perhaps in part water-lain, the beech consociation is distinctly characteristic.

The sugar maple—beech—birch—white pine—hemlock association of the higher plateau to the east extends into this region in a few places, notably through the Pymatuning Swamp depression in Crawford County and along the southern shore of Lake Erie in Erie County. In the first case, the depression is to be regarded as a slowly disappearing northern bog area, the tardy disappearance of which is, in part, probably due to cool spring waters feeding into deep depressions; in the second case, the influence of Lake Erie is evidently the dominant factor.

Sphagnum—Tamarack Bogs

During the northward migration of the vegetation, after the retreat of the glaciers, it would naturally be expected that in certain areas the conditions would for a longer time remain suitable for the more northern plants, and that more or less isolated areas or islands would be left behind, surrounded by the advancing vegetation of more southern character. The topography of the land previously covered by the ice, with its undrained or poorly drained kettle-holes and other depressions, naturally is more favorable to the retention of such boreal islands of vegetation than is that of the unglaciated area. There are, in fact, very few such boreal islands in the unglaciated area.

Such sphagnum-tamarack bogs as do occur in the unglaciated area are along the floor or at the head of valleys which are, as a rule, flat and choked with alluvial deposits and fed by cold spring waters. The most famous and characteristic of these bogs is known as Bear Meadows, among the mountains a few miles southeast of State College. Another such bog of small extent was near Larabee, Potter County, lying along a shallow wide valley.

In the glaciated area there was, formerly, a characteristic bog in a small kettle-hole depression near New Galilee, northwestern Beaver County; there is, at present, a small but characteristic bog around a small kettle-hole lake a short distance southwest of Mercer; the wide, flat-bottomed valley above Grove City still has a considerable number of tamarack trees; there is a small bog at the foot of Sandy Lake, Mercer County; in north-central Mercer County, Half-moon Swamp was formerly a characteristic bog of several acres; and in the southwestern corner of Crawford County there exists remnants of what was formerly a rather extensive sphagnum-tamarack bog, occupying an old glacial depression heading near Hartstown and extending north and northwest for several miles. There is another boggy swamp in northern Warren County, and there are probably others unknown to the writer. These examples serve to indicate, however, the rather widespread occurrence of the northern relict vegetations in the glaciated area of northwestern Pennsylvania. In some cases, the sphagnum and tamarack are about gone, due to lumbering and draining operations, and the interference in natural conditions by man seems to be resulting in aiding the southern vegetation to occupy the area sooner than it otherwise would. Probably originally in northern Pennsylvania, as is the case at the present time farther north, the black spruce would accompany and to some extent succeed the tamarack as the level of the substratum was built up, and, eventually, with the attainment of rather mesophytic conditions, the northern mesophytic forest of dominantly balsam fir would become the climax forest.

It is interesting to note that around none of the bog areas mentioned, with the exception of Bear Meadows, are there either black spruce or balsam fir trees. This, of necessity, means that when the bog basin has been sufficiently built up to present suitable conditions for a more mesophytic vegetation, the only available vegetation of that nature is the surrounding vegetation of more southern character, and, it seems that the succession generally for these Pennsylvania relict bogs is through a red maple—black ash swamp forest or perhaps in some cases directly into a forest dominated by white pine, hemlock, and red maple. This, probably, is transitional to the sugar maple—beech—birch—white pine—hemlock association so generally characteristic of the north-central plateau. At the lower altitude (about 1,000 feet above the sea) and with the incorporation of mineral soil materials in the depression, it appears, as in the western end of the Pymatuning Swamp area, west of Linesville, that the succession is through a red maple—black ash swamp, into a white elm bottomland forest, and probably from there eventually into one phase or another of the climax sugar maple—beech forest.

To summarize briefly, it may be stated that these bog areas are relicts of a northward-moving vegetation, and that they will eventually be succeeded by mesophytic stages of the more southern vegetation which has moved up around them.

Presque Isle

Along the shore of Lake Erie, at Erie, Pennsylvania, is a recurved sand-spit which has been gradually traveling along the shore towards the east. The sands wear away from the western end where it is attached to the shore and, traveling around to the eastern end of the spit, contribute towards its upbuilding and extension in that direction. From studies[19] made by the writer, it is evident that the peninsula has extended itself eastward about three miles in six hundred years. During that time the vegetation of the sand beaches has passed through a succession of stages: sand-plain or cottonwood ridge; bearberry heath; white pine forest; black oak forest; and, finally, hemlocks beginning to appear, this probably indicating the sugar maple—beach—birch—white pine—hemlock association, such as is present in places nearby, along the northerly-facing bluff along the shore of Lake Erie.

Altogether, there are a number of successions on Presque Isle, some beginning with ponds or lagoons, others with coves or bays, but no attempt will be made to discuss these associations here, other than to note that red maples are prominent in the swamp forest border of the oldest habitats of this kind (hydrarch). It is probable that the climax forest here, also, would be of the same type as indicated above for the portions of the peninsula which have passed through the sand-plain stage

[19] Jennings, O. E. A botanical survey of Presque Isle, Erie, Pennsylvania. Annals Carnegie Museum, 5: 289–421, 1909.

(xerarch). For details of the various plant societies and their sequences, see the publication noted above.

Pine Barrens

The pine barrens of the south-central part of Centre County and northern Huntingdon County should be noted in any sketch of the vegetation of Pennsylvania. They consist of rolling or nearly level stretches of the Morrison soils, sandy, with included small stones, very loose and porous, and deficient in humus. Being derived mainly from sandstones and quartzites in a limestone region, they have subterranean and rapid drainage and droughts are severe, and frequent.[20] The organization of the vegetation of these pine barrens is as follows:

Pitch Pine—Scrub Oak Association

Trees

Dominant: Pitch pine (*Pinus rigida*).
Secondary: Chestnut (*Castanea dentata*).
White oak (*Quercus alba*).
Black oak (*Q. velutina*).
White pine (*Pinus Strobus*).

Shrubs

Bear oak (*Quercus ilicifolia*).
Dwarf chestnut oak (*Q. prinoides*).

Small Shrubs and Tall Herbs

Sweet-fern (*Comptonia peregrina*).
New Jersey tea (*Ceanothus americanus*).
Blueberries (*Vaccinium pennsylvanicum* and *V. vacillans*).
Huckleberry (*Gaylussacia baccata*).
Wild sarsaparilla (*Aralia nudicaulis*).
Wild indigo (*Baptisia tinctoria*).
Bracken (*Pteridium latiusculum*).
Goldenrods (*Solidago juncea, nemoralis,* and *bicolor*).
Asters (*Aster undulatus, azureus, ericoides,* and *macrophyllus*).
Rough sunflower (*Helianthus strumosus*).

Low Plants and Cryptogams

Trailing arbutus (*Epigaea repens*).
Wintergreen (*Gaultheria procumbens*).
Shin leaf (*Pyrola elliptica*).
Moccasin flower (*Cypripedium acaule*).
Pigeon-wheat moss (*Polytrichum commune*) and other mosses.
Lichens (*Cladonia* spp., particularly).
Spotted wintergreen (*Chimaphila maculata*).

[20] Shaw, Chas. F. The soils of Pennsylvania. Penna. State College Agr. Exper. Sta., Bull. 132. Oct., 1914.

Should conditions become less xerophytic by reason of further reduction of the region, or by reason of the restoration of surface instead of subterranean drainage, the pitch pines would be soon succeeded by oaks, as already indicated around the edges of the barrens. The succession of vegetational stages would then fall into the same series of stages as the ridge series, which, like the pine barrens, begins with a forest of pitch pine. The vegetation of the pine barrens resembles that of the rocky ridge in that the foliage of the primary (tallest) layer of trees does not form a dense canopy and there are, further, almost no medium-sized trees beneath them.

Summary

The fundamental underlying principle upon which the vegetational associations and their successions must be based in central and western Pennsylvania is that the natural tendency is for the lands to be reduced and peneplained, with the result that a fertile, moderately moist (mesophytic) soil will become the general covering of the land, this soil being fitted for the highest ecological type of vegetation (climax) which the climate of the region will permit. In the climatic area occupied by central and western Pennsylvania it is believed that the sugar maple—beech forest association constitutes the climax, and this means, therefore, that in the process of reduction and peneplanation of the land, the various vegetational associations will displace and succeed each other as the conditions become more and more suitable until the mesophytic climax forest is reached.

At the close of the Glacial Period the zones of vegetation moved successively northward and it is believed that this movement is still in progress, relict areas or islands of "northern" plants or more or less isolated occurrences of one or more species of the northern plants being common in the northern part of the State. To briefly summarize, it may be stated that four outstanding features characterize the vegetation of central and western Pennsylvania, as follows:

1. Sphagnum—tamarack bogs, mostly in the northwestern (glaciated) part of the State, cannot follow out their natural ecological succession and become balsam fir—spruce forests, but, as they become sufficiently mesophytic, they will be succeeded by more southern mesophytic vegetational stages tending towards the sugar maple—beech climax forest.

2. The domed elevation of the Harrisburg peneplain in the north-central part of the State is probably responsible for a climate too cold for the complete dominance of the sugar maple—beech climax. With the reduction and peneplanation of this region, however, the climax may be expected increasingly to prevail.

3. The lower glaciated northwestern corner of the State has, by reason of its glaciated character, considerable areas of fertile and suitably mesophytic soils which have already been occupied by one phase or another of the sugar maple—beech climax forest.

4. The southern part of the State, from the region of Huntingdon westward, was not glaciated and it appears that much more important than the northward movement of the present vegetation are the processes of physiographic reduction, as to their bearing on the present successions. The Huntingdon region is much more strongly folded, the rocks more strongly metamorphosed and the hardest strata more resistant to erosive processes, than is the case successively westward. On account of the greater elevation and folding of the eastern ridges, erosion there has been generally most rapid and the remaining portions, the present ridges, generally represent rocky habitats which are the most unsuitable for plant life to be found in the whole State. With the reduction of these ridges, more and more suitable soils will clothe them, and, as one travels westward, the less folded and generally less metamorphosed ridges are likewise more and more covered with suitable soils. These facts mean, then, that from the rocky ridges occupied by the pitch pine forests, there follow (*a*) down the slopes of these ridges and (*b*) likewise to the westward along the "sky-line" areas of the ridges or uplands, a series of better soils and more mesophytic vegetational associations, ending finally with the fertile and moderately moist soils of the terraces, or flood-plains, or peneplained areas bearing naturally the climax sugar maple—beech forest. In a figurative way, then, through the southern half of the western third of the State, the plant associations appear to arrange themselves generally from the tops of these eastern ridges downwards and westwards towards the climax forest.

In this general outline but little attention has been paid either to the many transitional or mixed associations, or to the minor successions, such as those of ravines of different kinds, islands, etc., but it may be said that with increasing age and stabilization of the activities and results of erosion, accumulation of humus, and other factors, these minor successions relatively soon merge into the general succession and will, finally, end in the climax sugar maple—beech forest association, figuratively just as the branch streams of a river system finally merge into the one main trunk stream.

Pittsburgh, Pa.

ABSTRACTS OF PAPERS READ BEFORE THE ACAD EMY OF SCIENCE, NOVEMBER 28, 1924

SCALE INSECTS OF PENNSYLVANIA

By F. M. Trimble
Pennsylvania Bureau of Plant Industry

The economic importance of the Coccidae, or scale insects, is recog nized by plant growers throughout the world and the interest in th group in the United States has been unusually strong since the introdu tion of the San Jose scale in California about 1870. This family is repr sented in the fauna of Pennsylvania by 109 species. In 1917 only 4 species had been recorded in the State but subsequent explorations by th writer and other members of the Bureau of Plant Industry have reveale 67 other species, three of which are new to science. Although only 1 of the total number are economic pests on out-door plants yet these ar sufficiently abundant at times to cause enormous losses if not controlle by mechanical means. In greenhouses and conservatories, nine speci have been recorded as generally injurious.

The peculiarities in form and habitat of this family are not unli those of many other families of insects and the amateur must close scrutinize infested plants in order to find many of them.

INVESTIGATION OF AVAILABLE ROAD-BUILDING MATERIALS IN PENNSYLVANIA

By H. S. Mattimore
Pennsylvania Department of Highways

In 1924 the Department of Highways used approximately 2,540,0 tons of stone and 650,000 tons of sand for road purposes. In a favora season, with a large construction program, the quantity of material us would be much greater. Much of the material is supplied by comme cial plants, but in some counties, where there are no commercial pla or railroads within reasonable hauling distance of a construction job, is necessary to discover and develop a local supply. Geologic maps a a knowledge of rocks and minerals aid in the selection of a site, but t final determination of quality is made by laboratory tests.

Rocks available in the State and suitable for highway purposes are limestone, trap, granite, gneiss, and some quartzite and sandstone. Diabase or trap, granite and gneiss have given excellent results. Some sandstone, quartzite and conglomerate pass the requirements, others are valueless for road-building. Siliceous limestone and dolomite are more satisfactory than high calcium and argillaceous limestones.

SURVEYING FOREST SOILS

By J. T. Auten
Pennsylvania State Forest School

We are confronted with the restoration of millions of acres of forests, that our posterity may enjoy what our forefathers have wasted. The problem is how to do this most quickly, effectively, and permanently. If the abandoned acres are allowed to reforest themselves by natural processes, are we sure they will produce most efficiently at maturity? We need to establish a great foundation of fact regarding the fundamental conditions of efficient, permanent growth.

Our knowledge of forest soils is very meagre. Soils are classified by texture or size of grain, by their percentage of clay, loam, sand, and organic matter. Texture largely determines the water-holding capacity and aeration of a soil, and these influence the bacterial life. Soil organisms are indispensable to plant growth.

In the Mont Alto State Forest conifers flourish in certain well-defined areas almost to the exclusion of hardwoods. The soil in these areas is markedly different and coarser from that of immediately surrounding areas. Is the limiting factor for conifers one of aeration and the consequent nitrogen fixation, or is it merely that the hardwoods cannot exist on the smaller amount of moisture? We do not know. The roots of conifers bear fungus growths and nodules. Is it not likely that the conifer has a nitrogen-fixing symbiosis similar to that of the legumes? If a certain soil is best fitted for conifers, why allow other kinds of trees to occupy that soil and produce inefficiently?

The important factors in a soil survey are: (1) Drainage or moisture conditions; (2) quantity and kind of organic matter; (3) acidity and its influence on tree growth; (4) plant food available and the requirements of different kinds of trees.

A detailed soil survey of the 23,000-acre Mont Alto State Forest was begun in 1924 as a basis for a reforestation policy.

METAL POISONING IN PEACHES

By W. A. McCubbin
Pennsylvania Department of Agriculture

In 1922 the writer's attention was called to a sickly condition of young peach trees in Franklin and Adams counties which could not be correlated with our ordinary peach troubles. The same condition has been noted in York, Berks, and Cumberland counties, and what is apparently a similar trouble has been recorded by Dr. Mel. T. Cook in New Jersey.

The foliage of affected trees becomes yellowish in midsummer, the leaves roll upward, have a tendency to sunburn readily, especially along the edges, and fall long before their time. When this symptom appears in summer, further terminal growth is stunted and the setting of buds for the succeeding year is interfered with. Affected trees remain stunted and small in size, though neither twigs nor foliage show signs of starvation.

The symptoms clearly suggested a drought effect, so much so that in the dry season of 1923 this was considered a possible cause. Failure of the trees to recover upon the advent of wet weather, as peach trees readily do in cases of drought, led to the search for some other cause than mere lack of water. Careful examination eliminated any of the common fungi or insects above ground from consideration and led to study of the root system. This was found to be normal except that the majority of the small roots and rootlets were browned and dead. Frequently new rootlets had pushed out at the bases of the dead portions only to be killed in turn. Root-hair areas, where they were still present, were scanty in extent and the root-hairs abnormal. Here was the undoubted cause of the drought symptoms in the tops, but what had killed the rootlet system on so large a scale?

Some attention was given to possible fungus parasites, but since many dead roots showed no evidence of mycelium in their tissues and all the fungi found associated with the injured roots are such as one meets with constantly in the soil, the theory of a parasitic cause for the injury was badly shaken.

The owner of one of the worst affected orchards stated that before his peach orchard was planted he had never been able to grow corn in this field. This suggested a soil condition recently associated with corn root rot, in which, owing to the unbalanced nature of the soil chemicals, there is an undue absorption and accumulation of the salts of iron and aluminum in the lower stalk, with consequent weakening and breaking down of the tissues to a point where root rot fungi are able to attack them energetically. Tests of corn adjacent to one of the affected orchards in 1924 showed plentiful accumulation of these metals in a large number of sickly stalks.

A series of fertilizer plots were run on the orchard of W. C. Weaner, of Bendersville, in 1924, designed to test the value of fertilizers in restoring normal soil conditions. These included nitrogen, potash, phosphate and lime alone, a complete fertilizer including lime, nitrate and potash, phosphorus and lime, and potash and phosphorus. These applications were made in varied amounts in early spring and worked into the soil by immediate cultivation.

The results were striking. Two of the plots, and these alone, responded immediately, made luxuriant growth during the summer and developed normal, dark-green, unrolled leaves. The others remained, to all appearance, like the rest of the orchard, which even in a season of abundant moisture developed the same drought symptoms as before. The two plots showing improvement were (*a*) the one with complete fertilizer, and (*b*) the one having nitrate and potash. Since nitrate and potash occur together only in these two plots, and since none of the chemicals applied alone gave any results, one is justified in suspecting that here, as in the case of corn, both elements are necessary to restore the soil balance and thus prevent harmful effects from excessive amounts of the soluble salts of iron and aluminum.

It must be admitted that the evidence given is scarcely sufficient to permit any final conclusion, but it does give a strong indication of the probability of poisoning from metal salts, and if future results confirm this view the range of the toxic action of free iron and aluminum salts may have to be extended to include orchard trees as well as the corn, barley, rice and other plants heretofore known to be affected by this so-called "metal poisoning."

SOME RECENT DEVELOPMENTS IN LARGE CENTRAL STATIONS

By Joseph Razek
University of Pittsburgh

The phenomenal increase in the use of electric power and the increasing cost of fuel has forced the adoption of many refinements in station design, which, although known for some time, were considered of purely academic interest. This paper discussed three of these refinements. Two are quite old, but their recent adoption has brought about the devel ment of the third.

The adoption of the representative cycle, the air preheater, and water-cooled furnace wall (the three refinements discussed) seem to low one another logically. The use of high feed water temperatures fo the adoption of the air preheater, which in turn will probably lead to wider use of the water-cooled side wall furnace.

The regenerative cycle was suggested many years ago and was u with large pumping stations before 1900. The air preheater has b used in marine practice for some years, but its adoption in station plants in this country is recent. The water-cooled furnace wall i recent extension of the water-cooled screen used in furnaces for pul ized coal.

The reason that these developments were not adapted earlier is t they could not show a saving at the comparatively low fuel prices vailing until recently. Even though a development may promise mu its adoption can only be justified if the savings obtainable through gain in efficiency are greater than the increased maintenance and ca cost. The power plant engineer must be guided not only by the fun mental laws of physics and chemistry, but also by the equally fun mental, though often less obvious, laws of economics.

Another new development in central station practice is the us pulverized fuel, which has made possible the efficient use of low-gr fuel. Steam generation at elevated pressures is being discussed and t installations are in course of construction. The use of mercury va promises high efficiencies.

THE PEARL ORGAN PROBLEM

By Norman H. Stewart

Bucknell University, Lewisburg

Pearl organs in fishes have nothing to do with pearls. They ar fact little horn-like elevations of the epidermis that develope on the of many of our native fishes in the spring of the year. They are pe like only in color and translucency. Each is a sharply circumscri thickening of the epidermis, being made up of ordinary epidermal c that is to say, no specialized cells such as club-shaped cells, mucus, ly or nerve cells occur in them. The core of the little horn-like orga composed of concentrically arranged cells of the stratum lucid Above this the stratum corneum is likewise thickened and elevated a sharp or rounded papilla.

While all pearl organs agree in structure, color and texture, they iffer markedly in size, form and distribution. They are confined to the nale sex except in the case of the black and the white sucker and the hiner, *Notropis braytoni*. They are of seasonal appearance, being noticeble first in the fall or early spring and being shed after the breeding eason in the early summer.

Interest arises when we seek to relate these organs to use and to acount for their distribution on each species. The fact is well established hat the distribution on the body of any fish is a specific character, that s the pattern on two males of the same age is the same within a given pecies. But when we compare species the widest variations occur. Most f us are acquainted with them on the common chub where they form row of four or five large ones (3 mm) over the eye and have given rise o the name "horned chub." But on the blunt-nosed minnow they are onfined to the snout, while on other cyprinoids they adorn various parts f the body except the ventral surface. They even form specific patterns n the epidermis overlying each bony scale. Some thirty species have een described and drawings made of their pearl organ patterns. No two ave yet been found to be identical.

Professor Reighard (1910) concludes that to a varying extent some ishes have found a mechanical use for these organs. He finds that they mploy the regions roughened by pearl organs in maintaining contact f their bodies during spawning. The author agrees with this interpreation of their partial use, as white suckers have been examined in which he epidermis of the body of the female has been severely eroded by the oughened body of the males. But the result of a careful comparison f the spawning attitudes of several species with their pearl organ disribution leaves no doubt that many of them are not useful and Reigard's terms effective and non-effective pearl organs are well chosen. We seem to have here then structures that are of the nature of excresences, for which some species have found a use. We may at least be safe n concluding that Lamarckian factors (use, etc.) have not produced hem. This is especially evident when we find totally different patterns n species with almost identical habitats, and vice versa.

PRE-CONCEPTIONAL SEX CONTROL

By H. D. Fish

University of Pittsburgh

No abstract.

FORAMINIFERAE IN THE DETERMINATION OF OIL DEPOSITS

By George H. Ashley
State Geologist

No abstract.

SEROLOGICAL STUDIES IN THE CONTROL OF HOG LUNGWORMS

By Geo. Zebrowski
Professor of Biology, Villanova College

Studies conducted with different extracts of the two species of hog lungworms *Metastrongylus apri,* and *M. brevivaginatus,* indicate that specific antibodies can be built up in the host against the specific protein of these worms. Extracts were made of dry lungworm powder, by triturating half a gram of the powder with 100 c.c. of physiological salt solution, alcohol and 50 c.c. of ether. These extracts were rendered sterile by filtering, and then injected into pigs and other animals; five injections being given of each extract at five-day intervals. Where these extracts were injected into pigs the dosage was as follows: 10 c.c., 20 c.c., 30 c.c., 40 c.c., and 50 c.c. for the last injection. Into rats and guinea pigs injections were made of the ether and salt solution extracts in the proportion of one cubic centimeter to 100 grams of body weight. Much smaller doses were given of the alcohol extracts.

The above, and similar tests, showed that alcohol extracts of lungworm powder were highly toxic to the animals into which they were injected. When living lungworms and lungworm larvae were introduced into the blood of such treated rats, they showed marked irritation and the larvae died after a few hours. The adult worms taken from the lungs were apparently not affected. In normal rat and pig blood the larvae remained alive for seven days, when the cultures were discarded due to putrefaction of the blood.

Tests similar to the above, conducted with ether and alcohol extracts gave negative results, *i.e.*, the larvae and adult worms remained alive in the blood of such treated animals for three days when they were discarded. Anaphylaxis could not be produced in animals injected with these extracts. They were also non-haemolytic when left in contact with washed blood corpuscles of rat, pig, and human blood for ten hours. Animals injected with these extracts showed no ill effects even when injected with excessive amounts.

It was assumed, in performing the above experiments, that if any toxins were given off by the parasites they should stimulate the production of antibodies in the body of the host and that in turn these antibodies should have some effect on the parasites. It was found that alcoholic extracts of lungworm powder did stimulate the production of antibodies in the bodies of animals into which they were injected, and that such antibodies would kill living lungworm larvae which were introduced into the blood of the treated animals. The alcoholic extracts were found to be highly toxic, non-specific, and haemolytic in action. Apparently, immune bodies can be elaborated in response to their action.

These studies are still being continued to determine if a practical method of immunization can be devised. A detailed exposition of the experiments given in this summary will be published in the Proceedings of the Indiana Academy of Science.

BLACK GRANITE OF NORTHERN BUCKS COUNTY, PENN.

By R. W. Stone
Pennsylvania Geological Survey

The so-called black granite that is quarried at several places near Quakertown, and used mostly for cemetery monuments, is fine-grained, hard, crystalline, and takes a high polish. Chemical analysis shows that the rock is composed of: Silica 52 per cent., alumina 15, iron 13, lime 11, and magnesia 9 per cent. This is the typical composition of the Triassic diabase so common in eastern Pennsylvania and northern New Jersey. Furthermore, petrographic examination shows that the rock is composed essentially of plagioclase, augite and magnetite. The plagioclase feldspars are lath-shaped and automorphic, and the augite is xenomorphic. This is the ophitic or typical diabase structure and we must conclude that the rock is not a granite. It is typical diabase.

THE RUSTS OF PENNSYLVANIA

By C. R. Orton, H. W. Thurston, Jr., and F. D. Kern
Pennsylvania State College
(Presented by C. R. Orton)

This list is based largely on collections made by the authors during the past twelve years and deposited in the herbarium of the Pennsylvania State College. In addition the herbaria of the State Department of Agriculture at Harrisburg and the University of Pittsburgh have been freely consulted. These sources are represented by several collections each.

The rust flora of the State is represented by 154 species of rusts. The nomenclature of the North American Flora is followed throughout and the species are distributed in three families and 27 genera. Of the 154 species, 80 are heteroecious, 69 autoecious and there are five whose life history is unknown. Two species are known on ferns, 33 on Gymnosperms, and 119 on Angiosperms.

The host plants recorded represent 61 families, 172 genera and 368 species. The distribution in the State is recorded by counties and while some regions may be represented by comparatively few collections it is believed that the list is fairly complete. Additions are still being made, pending publication, and the authors will be pleased to receive collections of rusts from anyone in the State who is interested.

BORDER LANDS OF THE SCIENCES

By Benjamin L. Miller
Lehigh University

Many of us can recall the period in which it seemed comparatively easy to determine both the boundaries and the contents of the respective natural sciences. But in recent years, with an increase of research work in all lines, the border lands have been entered upon and we are finding that our old boundary lines between the various sciences do not exist. The time seems to have arrived in which the most fruitful lines of investigation are confined very largely to the former border lands. This is shown by the various combination terms that have come into existence such as Physical Chemistry, Bio-Chemistry, Physiological Chemistry, Geo-Chemistry, Geo-Physics, Astro-Physics and many others.

Each of the major sciences has now become so differentiated that no one can expect to be able to familiarize himself with more than a small part of the field. Notwithstanding the breadth and numerous branches of any particular science, still we are largely concerned with the border lands where two or more of the distinct sciences of an earlier day now meet. Specialization is breaking down the barriers and the inter-relationships are assuming greater importance. The psychologists explain mental processes by physiological principles, the physiologists seek explanations in chemistry and physics. "The chemists and physicists are busily engaged in the attempt to show that all the phenomena of their sciences ultimately depend solely upon the laws of matter and energy—perhaps of energy alone." Our specialization in all directions seems to prove the underlying simplicity or unity of nature.

In our colleges and universities of the present day we must train men for specialized work in their researches, but it appears that it is becoming necessary for a man to become firmly grounded in at least two sciences if he expects to make important contributions to the sum of human knowledge. Taking geology as an example, we find that the man who expects to do work in economic geology would do well to spend much time in his study of physical chemistry, the paleontologist or stratigrapher must be an expert in biology and geography, the vulcanist must be a student of physics, etc.

But even the broadly trained scientist is sure to encounter difficulties in his investigations in these border lands. Cooperation of the workers in allied sciences seems necessary in which the same problems are attacked from two or more sides by specialists of different training. The geologist and the chemist, the chemist and the physicist, the astronomer and the physicist and many other combinations or partnerships must combine their efforts. Joint researches of this kind afford the greatest promise of valuable contributions to the many unsolved problems of these border lands.

In addition to the combination of scientific workers, helpful results are sure to be obtained by symposiums in which problems common to many fields may be discussed by workers in the different sciences. Therefore it seems appropriate to make use of meetings of various kinds that bring together different groups of scientists for the discussion of border land subjects. Symposiums of this kind seem most profitable for such gatherings as those that bring together all the scientific men of a university faculty, the faculties of several colleges or universities, or in such an organization as the Pennsylvania Academy of Science. It is the opinion of the writer that symposiums of this character will do more to stimulate valuable researches than the more limited discussions among men of the same general training.

EXTENDING PENNSYLVANIA'S STATE FORESTS

By E. A. Ziegler
State Forest School, Mont Alto

Pennsylvania is now purchasing four-fifths of its lumber and much of its other wood needs outside the State, to a total value annually of over $100,000,000. It has thirteen million acres of forest and scrub lands that are of value for no other use. These lands now are not worth over $10 an acre on an average. By protection and building up the growing stock these thirteen million acres may be developed into worth $150 per acre, or a total producing capital of over $2,000,000,000 in the next fifty or one hundred years. This will not require a relatively large money outlay, probably not over $25,000,000 for purchase, with a relatively small maintenance item until the forests become self supporting.

These 13,000,000 acres are held as follows:

1,000,000 acres in State forests.
4,000,000 acres in small holdings, mostly by farmers.
8,000,000 acres in larger holdings, generally unprotected.

How is this last 8,000,000 acres to be restored? Shall it be by national, state or private forestry?

In Pennsylvania the national government will care ultimately for about 500,000 acres on the Allegheny watershed. This leaves 7,500,000, or one-quarter of the area of the State, in private hands. It is possible that 2,500,000 acres will be reestablished in productive forest by wood-using corporations. This leaves 5,000,000 acres with no prospect of early forest reestablishment. Compulsory private forestry is impracticable. State ownership of this forest domain would achieve better results in a much shorter time and with considerable profit to the State.

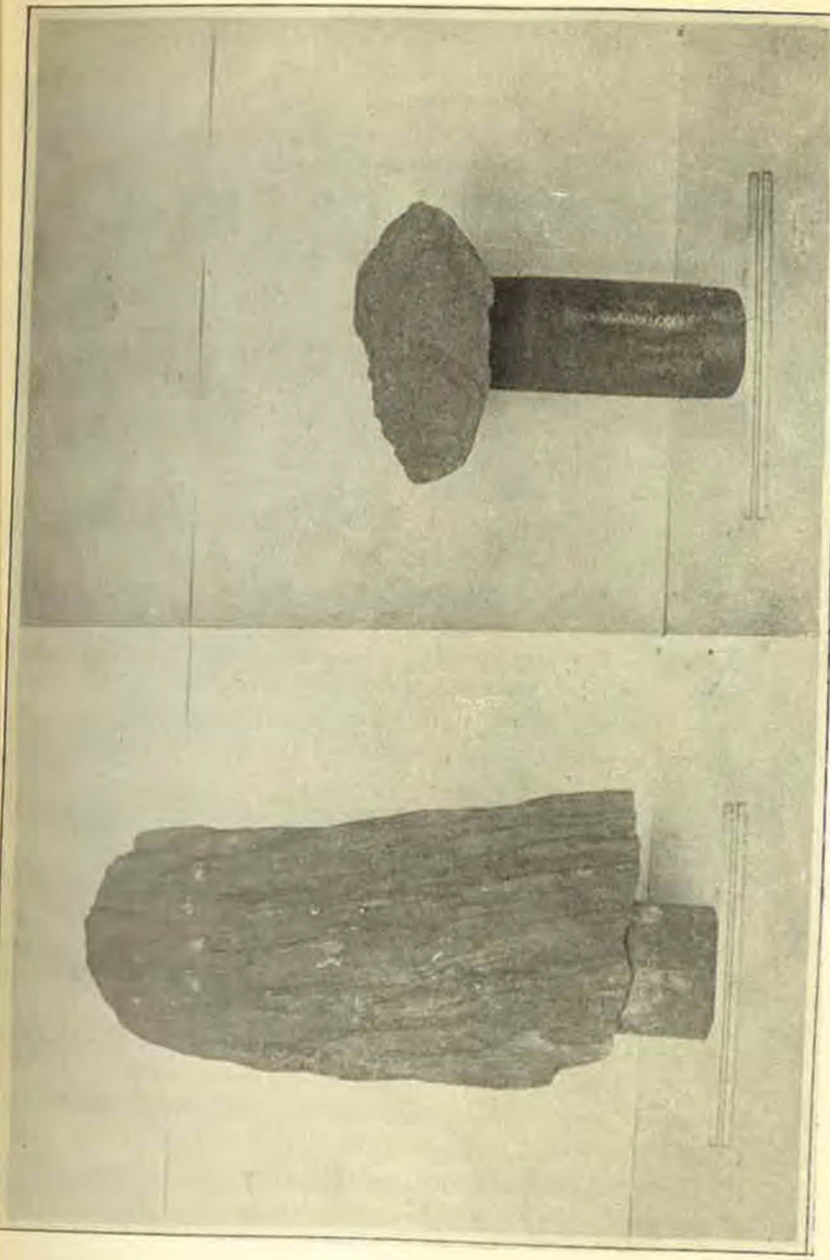
Building up these additional millions of acres of mountain land into productive forest would go far in furnishing State roads in these forests with a profitable traffic. Such traffic could absorb the maintenance cost of a large road mileage through the forest areas that now must be charged to other State income, since these areas are now largely unproductive.

The social uses of the State forests alone justify a comprehensive State forest policy, the first step in which is the acquisition of all the untended forest land offered up to 5,000,000 acres. The people should respond enthusiastically in the restoration of Penn's Woods, if the matter is presented in the proper social light.

PRELIMINARY NOTE ON A CALCIFIED LOG FROM THE PITTSBURGH COAL NEAR MORGANTOWN, WEST VIRGINIA

By Chas. R. Fettke
Carnegie Institute of Technology, Pittsburgh, Pa.

In 1923 the writer obtained a portion of a well-preserved log from the Pittsburgh coal near Morgantown, West Virginia. The specimen was taken from the upper portion of the coal bed in Mine No. 1 of the Connellsville By-product Coal Company at Barker, West Virginia. The log had been flattened before petrification set in so that it is now roughly lenticular in cross-section. The specimen, which is twenty-one inches long, represents only a portion of the log. At the broken end it has a



Views of Calcified Log from the Pittsburgh Coal Bed.

maximum diameter of eleven inches and a minimum of four inches. At the opposite end it tapers to a wedge. Plate VII shows the appearance of the specimen when viewed from different angles.

Other logs, similar to the one referred to above, occur in place in the coal at various levels. They were all in a horizontal position with their flattened surfaces parallel to the bedding of the coal.

Thin sections of the original specimen examined under the microscope show how well the cell structure of the original wood has been preserved. What appears to be a slight difference between early and late growth cells can be recognized if a large enough field is viewed with an ordinary pocket lens (Plate VIII). Figure 3, a radial section, magnified 20x shows medullary rays and tracheids along some of which the pits can be clearly seen. Figure 4 shows some of these pits magnified 75x. A preliminary examination reveals conifer-like structures indicating that the log may represent one of the cordaites.

A mineralogical examination of the specimen indicates that the replacing substance is largely calcite. Some pyrite is also present. A qualitative chemical analysis bears this out. With the exception of the pyrite and a negligible amount of carbonaceous matter, the material goes into solution readily in dilute hydrochloric acid with marked effervescence. Calcium carbonate is the chief constituent, associated with which are a little magnesium and possibly minute amounts of ferrous carbonate. A quantitative analysis will be made in the near future. The material selected for the purpose has a specific gravity of 2.962.

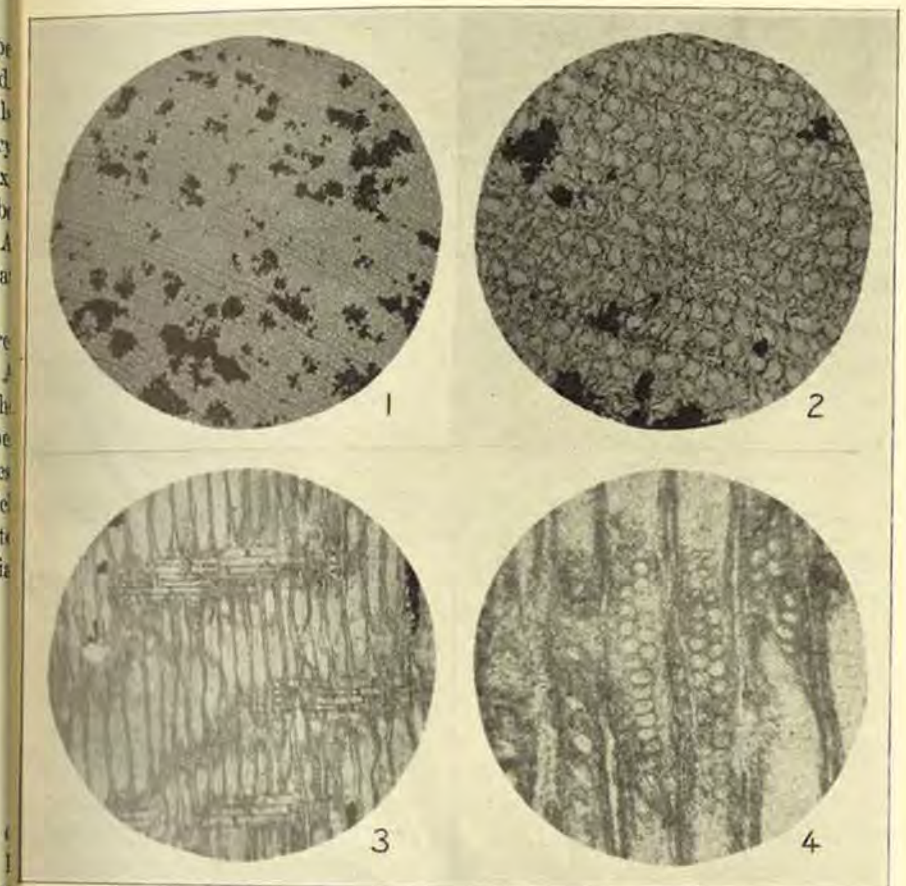
ECOLOGICAL DISTRIBUTION OF SOME FUNGI NEAR PITTSBURGH, PA.

By Hugh M. Raup

The problem here considered is the manner in which the layers of leaf-mould are tied together, from year to year, by fungus mycelia. If there should be a regular migration from layer to layer, of the mycelia of specific species, it would show a limitation on the distribution of the species. From the data it would seem that only one species observed is actually limited to a certain layer of mould, *e.g.*, *Marasmius siccus*. The species of well defined humus formations, *Russula emetica*, *Russula* (furcata?), *Lactarius* (species?), and *Amanita phalloides*, seem to be rather promiscuous in their distribution through these layers.

At several points there seems to be a correlation of the distribution of the fleshy fungi with that of the major vegetation of the region. *Amanitopsis vaginata*, *Lepiota americana*, several *Russulas*, and many ... interesting problems in this respect.

PLATE VIII



MICROSCOPIC SECTIONS OF CALCIFIED LOG FROM PITTSBURGH COAL BED.

1. Transverse section. ×4½.
2. Transverse section. ×20.
3. Radial section. ×20.
4. Pits along tracheids shown in radial section. ×75.

Distribution	Dead wood	Leaf mould, 1 yr. old	Leaf mould, 2 yrs. old	Leaf mould, 3–4 yrs. old	Leaf mould, age unknown	Humus—clay	Clay—open	Shaly clay	Clay — under humus	Insect pupae in humus	*Old chestnut burs*
Geoglossum sp.											×
Wynnia sp.									×		
Thelephora sp.							×				
Cordyceps militaris										×	
Xylaria polymorpha	×										
Scleroderma vulgare					×						
Crucibulum sp.								×			
Mutinus sp.					×						
Coprinus sp.	×										
Agaricus sp.							×				
Marasmius siccus		×									
Hygrophorus coccineus					×						
Russula roseipes							×				
Russula rubra							×				
Russula virescens							×	×			
Russula (furcata ?)			×						×		
Russula emetica			×	×							
Clitocybe ochropurpurea							×				
Lepiota sp.											
Lepiota americana									×		
Amanitopsis vaginata							×		×		
Amanita phalloides				×		×					
Pleurotus ostreatus	×										
Lactarius (red, 2″ dia.)			×						×		
Lactarius (tan)				×							
Lactarius volemus ? (brown)	×										
Lactarius piperatus ? (large—white)							×				
Lactarius (red, 4″ dia.)									×		
Boletus sp.							×	×			
Polyporus versicolor	×										
Clavaria pyxidata	×										
Clavaria mucida	×										

ABSTRACTS OF PAPERS GIVEN APRIL 10–11, 1925

SPOROBOLUS UNIFLORUS MUHL. IN PENNSYLVANIA

By E. M. Gress
State Botanist, Harrisburg

Sporobolus uniflorus, commonly called Late-flowering Dropseed, was found in September, 1924, growing in the sphagnum moss around Painter Den Pond in Sullivan County. So far as is known, this plant has rarely been found in the State.

Its general distribution is from Maine to Ontario and Michigan, and south to New Jersey.

It is a slender, glabrous annual grass growing from six to eight inches tall. The panicle, which is from one-third to one-half the length of the plant, is very delicate and loosely flowered. The spikelets, which are one-flowered, are about 1.5 mm. long.

DEMONSTRATION OF LIFE HISTORY OF EARTHWORM

By S. Hoffman Derickson
Lebanon Valley College, Annville

Earthworms are much used for laboratory study. The animals studied as types should be presented as completely as possible. As dealers do not supply the life history of earthworms, it is necessary for those desiring to present this study to make their own preparations.

Stages in the life history of the manure worms are readily obtained. Copulating pairs are found near the surface of the soil or manure at night or in the early morning and may be killed in hot formalin (5 per cent.). This hardens the secretion which binds them together and fixes the accessory copulatory organs on the twenty-sixth somite in a distended condition.

Cocoons may be found in spring and summer in manure or soil from a few inches to a foot below the surface. They are creamy white, 1 to 3 mm. long, shaped like a lemon. When the embryo develops they become darker, the color of the worm showing through the translucent capsule.

Embryos may be dissected from cocoons or the cocoons may be kept in moist earth until the embryos hatch. One or sometimes two embryos are found in a cocoon. We have found a few pairs fused at the anterior end.

The young worm emerges from the cocoon by pushing out at one end of the cocoon where it closed when it left the body of the parent. It may use the cocoon for a time as a shelter within which it retreats when disturbed.

A life history demonstration may include (1) an adult; (2) copulating pair; (3) fresh cocoon; (4) cocoon with embryo emerging; (5) empty cocoon; (6) young worm. Each specimen is sealed in a numbered glass tube, and tubes assembled in Riker Mount with proper legend. (See Plate IX.)

A DOUBLE TURTLE OF THE GENUS CHRYSEMYS

By V. Earl Light and S. Hoffman Derickson
Lebanon Valley College, Annville

This turtle of the species *Chrysemys picta,* or painted turtle, was found on the bank of Swatara Creek, near the village of Harpers, in East Hanover Township, Lebanon County, Pennsylvania, by Miss Carrie Hardig. It first attracted attention because of its being two-headed, and was kept alive for about three months after it was found.

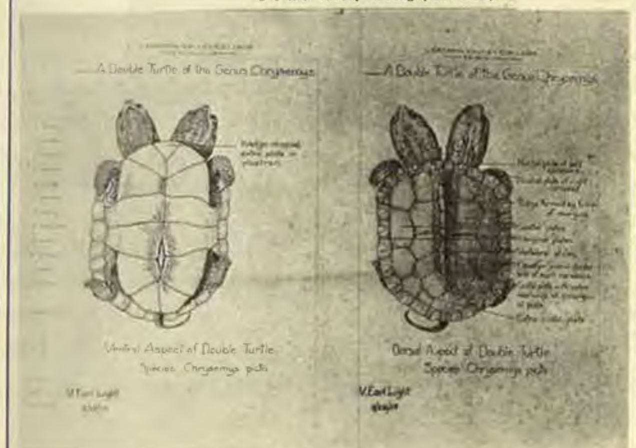
The specimen is normal in so far that it has four legs and a tail. Two heads of about the same size protrude from beneath the carapace. The carapace has about the same size and general shape as that of a normal turtle of the same age, but an elevation in the form of a ridge or crest extends along the mid-dorsal line from the anterior end of the carapace almost to the posterior end. The plastron has the same general shape as that of a normal turtle.

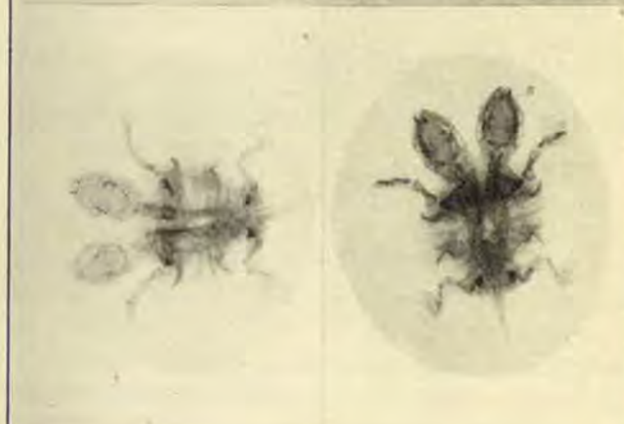
A more careful examination shows that the plastron, which in a normal turtle of the same species consists of twelve plates, in this specimen has thirteen plates. The extra plate is wedge-shaped, in the anterior part of the plastron, and lies directly beneath the angle formed between the two necks of the animal. (See Plate IX.)

The dorsal region is made up of two carapaces, having the right plates of the left carapace fused with the left plates of the right carapace. The ridge in the median line has the marginal plates of the two sides forming the crest of the ridge, and a normal number of costal plates forming the sides of the ridge.

Each side seems to have a normal number of vertebral plates, but the posterior vertebral plate on the right side is triangular in shape, and

PLATE IX





somewhat under size. A slight elevation extends along each side of the ridge on each of the five vertebral plates, which marks the mid-dorsal line of each carapace. These elevations come to a point just posterior to the crest formed by the fusion of the margins.

Counting all the plates on the carapaces, with the plates of the eleven fused marginal plates twice, there are: two nuchal plates, forty-seven marginal plates, ten vertebral plates, and eighteen costal plates, making a total of seventy-seven plates; in comparison with a normal turtle: one nuchal plate, twenty-four marginal plates, five vertebral plates, and eight costal plates, making a total of thirty-eight plates. This shows that the specimen has one extra plate in the carapace same as in the plastron, since two normal turtles have seventy-six plates, as compared with seventy-seven plates in this specimen.

A radiograph of the specimen reveals the fact that there are two distinct vertebral columns extending forward from a point in the region of the pelvic girdle. The pelvic girdle itself seems normal as far as can be seen with an X-ray. No vestiges of an extra pair of appendages are noticed, and the pectoral girdle seems to be divided, with each half shifted laterally toward the margin, each half attached to the vertebra beneath its corresponding vertebral plate.

During the time it lived, it was noticed that sometimes the two heads acted in one accord, and the turtle moved forward as a normal turtle would. Occasionally, however, if one head directed the body in one direction, and the other wished it to move in another direction, the left front foot attempted to move the animal in the direction directed by the left head, and the right front foot attempted to move in that directed by the right head, thus showing the fore legs and claws clawing the earth in opposite directions.

OBSERVATIONS ON HYDRA IN LIMESTONE SPRINGS DURING THE WINTER MONTHS

By Ray A. Troutman
Lebanon Valley College

(Introduced by S. H. Derickson)

The general impression prevails that it is difficult to obtain Hydra from their natural habitat during the winter months. A series of observations was made to ascertain the frequency of Hydra in the limestone springs in the vicinity of Annville, Pa., from January to March.

Relatively uniform quantities of aquatic plants upon which Hydra

are found were placed in two gallon aquarium jars in the laboratory. After 24 hours the Hydra were counted in each preparation and a record kept of the number.

A record was also kept of the temperature of the water and of the air, the depth of the water, the distance from the spring and the date of observation.

From the facts obtained we conclude that Hydra were abundant in January and that there was a gradual decrease in number from that time till March twenty-first.

The changes in the temperature of the water appear to have little influence on the number of Hydra.

The depth of water at which the Hydra were found varied with atmospheric temperature, the Hydra being more numerous at a greater depth when the atmospheric temperature was low and nearer the surface when the air was warmer.

The Hydra were more abundant five feet from the emergence of the spring than at a distance of twenty feet. The difference of temperature at these points was less than a degree. From these observations we conclude that greater frequency of the Hydra near the emergence of the spring was not due to the temperature factor.

From all data gathered we conclude that there are other factors than changes of temperature determining the number of Hydra at different periods and that Hydra may be obtained in considerable numbers from limestone springs during midwinter.

WEATHER CONDITIONS AT TOTAL ECLIPSES OF THE SUN PREDICTABLE; ALSO NOTES ON THE CORONA

By John H. Wayman
Pittsburgh

An exposition of an hypothesis that the weather condition at the time and on the totality line of a solar eclipse can be determined by a study of antecedent weather conditions.

NEGRO POPULATION INCREASE IN PENNSYLVANIA 1910–1920

By Dean Dutcher
Pennsylvania State Forest School, Mont Alto

A statistical analysis of the geographic origin and distribution of the increase of the negro population in Pennsylvania shows that the total number of negroes was 90,649 in 1920, or an increase of 15,540 over 1910. It gave the distribution by ...

groups. By far the greater number of these people live in cities and are between 20 and 44 years old.

The increase in negro population in Pittsburgh, by city wards, and the increase of negroes, 10 years of age or over, gainfully employed, by general divisions of occupations, by sex, for selected States, were given. As this population is largely urban, 83,000 as against 7,000 rural, the largest number of males are engaged in manufacturing and mechanical industries, and of females in domestic and personal service.

PROBLEMS OF CALCAREOUS CONCRETIONS IN STREAMS

By H. Justin Roddy
Millersville Normal School

The writer has found calcareous concretions in Little Conestoga Creek and Hostetters Run, Lancaster County; in Spring Creek, Centre County; and in Montours Run, Perry County; also underlying whole meadows bordering these streams. These concretions occur only in streams whose calcium bicarbonate content runs over 150 to 250 parts in a million, and where there is an abundant algal flora, especially blue-green algae or Cyanophyceae. The structure is concentrically laminated about a pebble, shell or piece of wood.

Laboratory experiments developed a coating of lime on pebbles, especially in acquaria having abundant blue-green algae and a lime content of more than 200 parts in a million.

Many streams with a calcium bicarbonate salinity as high as that of Little Conestoga Creek have no concretions. Big Conestoga Creek rarely has less than 176 parts of calcium bicarbonate in a million, has about the same species of algae as Little Conestoga Creek but in less abundance, has about the same chlorine content, and flows over the same kind of rocks, but Big Conestoga Creek has no concretions, and Little Conestoga Creek has them in abundance to its very mouth.

Big Conestoga Creek contains a varied and abundant molluscan fauna and fresh water bryozoa while the Little Conestoga does not. It is tentatively concluded that in Big Conestoga Creek the abundant molluscan life abstracts the lime from the water to form their shells and thus checks the development of an abundant algic flora and consequently checks the formation of concretions. Then, too, the molluscan fauna in their life processes may set free enough carbon dioxide to serve the purposes of the algic life. This in turn would render it unnecessary for the algae to abstract CO_2 from $CaH_2(CO_3)_2$. These ideas suggest some of the problems to be solved as to the origin and distribution of stream concretions.

AN UNUSUAL CASE OF LIMESTONE DECOMPOSITION

By Benj. L. Miller
Department of Geology, Lehigh University

As has long been recognized, limestones are eroded mainly by solution along joint and bedding planes by percolating surface waters. In this process there is little differentiation to be observed except in those limestones in which siliceous or argillaceous impurities are disseminated through the rock. There is ordinarily a narrow band of softened, partially decomposed limestone present but, in the case of massive compact rock, this is seldom more than one-half inch in width. This material can be rubbed off by the fingers. The contact between this pulverulent to sandy white product and the fresh rock beneath is usually very sharp. The undecomposed rock immediately adjacent to the rotten material does not seem to have been affected at all by the circulating solutions that evidently penetrate very short distances into the rock from the joint and bedding plane channels. Thus in most places we find residual clay separated from unchanged limestone by only an extremely narrow band of decomposed rock.

In contrast with the above, there is a striking example of limestone decomposition exhibited in the quarries of H. E. Millard and the Lawrence Portland Cement Company, a short distance west and northwest of Annville. In these quarries there are areas where pure compact limestone has been completely changed to a fine pulverulent powder which by slight crumbling in the hand can be made to pass through a 200-mesh screen. The areas of decomposition are irregular, ranging from 20 to 200 feet in diameter and extending downward to a depth of 60 feet in some places. The bedding and joint planes can be seen in the decomposed material and can be traced into the unaltered beds of limestone with no apparent distortion or displacement.

An entirely satisfactory explanation for this phenomenon has not been found as yet. Microscopic examination has shown that solution has apparently removed the exterior of the minute crystals of $CaCO_3$ constituting the rock, but why the solution penetrated the rock and dissolved portions throughout and not along the circulation channels is not apparent. The present position of the strata and the topography do not indicate that ground water would remain stagnant in these places for such a period of time that the rocks became thoroughly saturated with ground water, whereas the other areas adjoining were not, but it is possible that at some time in the past this might have been the case.

This chalky material has been used somewhat in the manufacture of Portland cement, although it is difficult to handle, and now is being quarried, bagged and shipped for agricultural purposes.

THE RELATIVITY ENERGY EQUATION AND THE VARIATION OF THE MASS OF ELECTRONS WITH VELOCITY

By Marsh W. White and W. R. Ham
Physics Department, The Pennsylvania State College

The Newtonian concept of mass has been altered in Relativity Theory to take account of an increase in mass as the speed of the body approaches that of light. The variation in the mass of high velocity electrons has been studied experimentally by Hupka and others. Assuming that all of the energy supplied by the potential difference existing between cathode and anode goes into the energy of the moving electron and its field, and taking this energy as given by the Relativity Energy Equation of Einstein for the kinetic energy of a moving body, namely,

$$W = Ve = m_o c^2 \left\{ \frac{1}{(1 - v^2/c^2)^{1/2}} - 1 \right\}, \qquad (1)$$

together with the Lorentz-Einstein relation for the variation of mass with velocity, namely,

$$m = \frac{m_o}{(1 - v^2/c^2)^{1/2}} = \frac{m_o}{(1 - \beta^2)^{1/2}}, \qquad (2)$$

these observers found that the data obtained fitted within experimental error the above equations. In these equations m is the mass of a body moving with a velocity v, m_o is its "rest mass" or mass when moving with a velocity negligible in comparison with that of light, c is the velocity of light, $\beta = v/c$, and V is the voltage through which the electron of charge e has fallen.

The conclusions reached by these workers must necessarily stand or fall upon the validity of their *assumption* that W in the equation $W = Ve$ correctly represents the energy of the moving electron and its field. It is by no means inconceivable that this assumption may be incorrect. For example, the emission of any radiation at or near the cathode would require that W be less than Ve, as would the acceleration of positive charges at the anode during the acceleration of the electrons stream

proper. It is the purpose of the present investigation to test the validity of this assumption.[1]

A measure of the energy of electrons with velocities up to 25,000 equivalent volts was obtained by noting the temperature rise of the oil bath in which was immersed a Coolidge X-ray tube supplied with a precisely measured quantity of energy. The current and voltage supplied to the tube from a high potential d. c. source was precisely measured and kept constant by potentiometers. Various runs were made under practically identical circumstances except that the voltage across the tube was changed and the current proportionately varied so that the total power remained constant. To compare the energy of the "high potential" electron stream with the same quantity of "low potential" energy, alternate runs were made, wherein a precisely measured quantity of energy was supplied from a 25-volt storage battery to a heating coil immersed in the oil bath. The data obtained from these experiments indicate, with a probable error of about 0.2 per cent., that the heat energy output from a Coolidge tube is exactly equal to the energy input. Hence there are no appreciable sources or sinks of energy in the tube, as would be obtained, for example, from transmutation of the atoms in the target.

Another series of experiments was made to prove that no appreciable fraction of the energy input goes into heat generated or absorbed at the cathode. The cathode does not appear to be in any way affected by turning the high potential on or off. Hence so far as we know at present all of the input energy must be carried by the electron stream itself, *i.e.*, W in the equation $W = Ve$ has been correctly interpreted. It is to be noted, however, that no one to date has shown that the anode is not in any manner affected before the electrons actually strike it.

The assumption by Hupka and others that the energy of the moving electron and its field is given by $W = Ve$ therefore seems justified. The present work thus puts the Relativity Energy Equation on a firmer experimental basis.

[1] These experiments are more fully described in a paper now in the press of the *Physical Review*.

UNDERGRADUATE FINANCE AND STATISTICS COURSES ADMINISTERED BY THE DEPARTMENTS OF MATHEMATICS OF PENNSYLVANIA COLLEGES AND UNIVERSITIES

By H. S. Everett
Bucknell University

48 Colleges addressed.
41 replied.
7 did not reply (1 large institution and 6 small ones).
19 now offer in the Department of Mathematics courses in Finance or Statistics or both ranging from 2 to 21 semester hours.
2 plan definitely to introduce such courses next year.
5 plan definitely to increase their offerings next year.
2 are considering such new courses.
1 is considering additional courses.
23 therefore are now giving or plan in the immediate future to give such courses.

Distribution of Amount Now Given

Semester hours	Colleges
2	2
3	5
4	2
6	3
8	2
10	1
11	1
21	1
indefinite	2
Total	19

These figures represent an encouraging situation, indicative of growth, and they show that the departments of mathematics in the colleges and universities of Pennsylvania are seizing an opportunity to enrich their curricula by providing courses that involve not real problems and methods alone but rigorous mathematical theory, order, and development as well.

These figures indicate furthermore a development that merits the active support and hearty cooperation of this Academy and of every other scientific organization throughout the State.

A DISCUSSION OF HELICOIDS AND HELICES BY VECTORS

By Joseph B. Reynolds
Lehigh University

In this paper the author treated helicoids as ruled surfaces generated by a vector normal to a given plane curve at a current point P, and making a constant angle with the plane of the curve. The envelope of all such vectors as the point P moves along the plane curve is a helix. By elementary methods of vector analysis many of the properties of helicoids and helices were set forth with simplicity and directness. The motion of the triad of mutually perpendicular vectors tracing out the spherical indicatrices of the helix was demonstrated and clearly described.

FOSSIL IVORY

By R. W. Stone
Pennsylvania Geological Survey

Both modern and fossil ivory are articles of commerce and used for many purposes. Small objects, like beads for necklaces, may be cut with little or no regard to direction of grain or location within the tusk, but larger objects will become distorted unless allowance is made for the difference in amount of shrinkage along the long and short axes of the tusk. Billiard balls must be centered exactly in the tusk and as originally cut are ellipsoidal because ivory shrinks along the length of the tusk more than across the diameter.

A 1-inch disc cut from a fossil tusk 6 inches in diameter after exposure in the dry atmosphere of the writer's home for three or four years, developed fine concentric cracks near the edge and separating the so-called bark from the main mass. Later a few radial cracks appeared and then hairline concentric cracks well in toward the center. In ten years the shell or bark was wholly detached by the shrinkage of the main mass.

As evidence of the uneven shrinkage due to difference in texture the ivory handle of a gavel was exhibited. This handle, 6 inches long, was perfectly straight in 1915. One side is fine-grained, the other is coarse-grained, perhaps the inner pulp of a tusk. The handle now makes an arc diverging ¼ inch from a straight line. This demonstrates the consideration that must be given to the location of an object within a tusk before cutting begins.

OBSERVATIONS ON PEACH YELLOWS

By W. A. McCubbin and F. L. Holdridge
Pennsylvania Bureau of Plant Industry

Peach yellows is generally accepted as belonging among the virus diseases. It has been of considerable importance in the southeastern peach counties of the State for many years and the Pennsylvania Department of Agriculture now inspects peach orchards in these counties each summer. In the course of this inspection in 1924 two series of observations have been made which seem worthy of record.

The first concerns the reliability of spring symptoms in diagnosing yellows. It would be of advantage to detect the disease in spring so that affected trees could be so much earlier disposed of. It has long been noted that trees with yellows may start growth in spring somewhat earlier than healthy trees, thus providing in their earlier opened leaf and blossom buds an outstanding symptom very early in the season. Is this early blooming reliable as a symptom of yellows? To answer this question three large orchards were inspected April 26 at blooming time and all trees showing forced bud development or abnormally early blooming were tagged. In July a second visit was made for the usual inspection and all yellows recorded.

The results of the two observations were put in three categories: (1) Tagged trees which later showed yellows; (2) tagged trees which showed no yellows in midsummer; and (3) trees which had not been tagged but which showed disease in the summer inspection. If all yellows found in the second visit could be placed in the first group it would give a strong indication that the early spring inspection was reliable; but unfortunately such a large proportion of the cases of disease fell into the second and third groups that we are forced to the conclusion that early development in spring is not an infallible sign of yellows.

The second observation relates to the possible spread of yellows through nursery stock, which has long been a popular belief. The methods of inspection used by the Department of Agriculture are complete for each block of trees, and by means of a questionnaire the nursery origin of 158 orchards containing 157,796 trees was obtained. These records were then united with the inspection records and each orchard listed under the nursery from which it came. If any nursery was spreading yellows stock far and wide its list of orchards thus compiled would show it as a general high percentage of the yellows found in inspection.

The lists showed no such nurseries; analysis from all angles did not cast suspicion at any nursery either in or out of the State. The result of this analysis therefore must be taken to mean that our peach nurseries are of at least minor importance in the spread of peach yellows.

SOME LIFE HABITS OF APHIS RUBIPHILA PATCH

Floyd F. Smith
Pennsylvania Bureau of Plant Industry

Of the various diseases affecting raspberries those included in the class of systemic diseases are the most destructive. Mosaic and leaf curl are two important diseases in this class, and extensive studies of these by various workers have failed to disclose any mechanical means of transmission. Among several insects used in transmission experiments *Aphis rubiphila* Patch has proven to be the only carrier. Successful inoculations of healthy plants with either leaf curl or mosaic have been made by transferring to them aphids of this species which have first fed on a plant affected with that particular disease.

The writer has observed the following life history and habits. The shining black eggs are laid by the wingless females on the raspberry canes—tucked in the axils of the buds, in crevices of the bark, or in Anthracnose sori. In early April at the time of the hatching of the eggs, the leaves are just separating from the buds and are about 1/4 inch long. The young nymphs crawl to the buds and work their way down among the leaves. In a few days, after the shoots have lengthened out, the aphids may be seen settled about the base of the new growth with their beaks inserted into the young tissue close up under the old bud scales. Reproduction takes place and the young settle down near the stem mothers, often so close as to force many individuals to rest upon others with only their head and beak reaching down to the plant stem. A hundred or more individuals have been noted in such a compact colony and with plenty of tender shoot growing out from them.

A few winged individuals appear in the second generation, more in the third, and a large number in the fourth. Up until the fourth generation the aphids remain in the compact colonies, but with the maturity of this one in early June there is a general dispersal of the individuals. About this time scattered wingless individuals appear on the under leaf surfaces. These summer forms have, as a rule, only five antennal segments while the spring forms have the usual six segments characteristic of the genus. These mature and reproduce for a number of generations during the remainder of the summer. Very few winged individuals develop on the leaves during the summer and in the fall, about November 1, the wingless sexual forms are mature. The males are small lemon yellow and dusky colored individuals about 1/3 the size of the females whose general color is brick red. Mating occurs on the leaves after which the females descend the petioles and lay two or three eggs each about the buds. Death occurs soon after egg laying is completed. Probably ten or eleven first born generations occur in a season, four at the base of the growths and six or seven on the leaves.

Two peculiar things about the habits of this insect are of interest. First is the feeding at the base of the growth in the spring in the compact colonies, and then the sudden dispersal and the feeding for the remainder of the season on the under leaf surface where the favorite point of inserting the beak is in the angle formed by the junction of a lateral vein and the mid-rib. Second is the change in the rate of reproduction. Individuals of the spring forms produced from 32 to 36 young each generation, but those on the leaves have been noted to produce from 6 to 7 young each.

The activities of certain predators as the lady beetles, *Hippodamia convergens* and *Adalia bipunctata*, and of a small Hymenopterous parasite, *Aphidius* sp., generally so greatly reduce the apterous individuals in the colonies that but few are present at the time of dispersal.

THE ESTHETIC VALUE OF BIRD LIFE

By George Miksch Sutton, Sc.D.
Pennsylvania State Game Commission

That most birds are economically valuable on account of their insect-eating habits has long been recognized. In fact there is a widespread belief among bird lovers that birds are the only creatures which prey upon insects. The ardent amateur bird student too easily forgets that there are some insects which are not enemies of the human race, that there are insects that prey upon other insects, that nearly all our batrachians and reptiles are insect consumers, that such mammals as bats eat virtually nothing but insects—that, to put it briefly, there are many other factors than the birds, which are regulating the abundance of insect life.

Insect consumption, oftimes the basis for popularity, is not a proof of a bird's economic value. The house wren is praised for capturing spiders, which themselves destroy many insects; the purple martin is praised for destroying dragonflies, dreaded for the mythical bite, but possessing a voracious appetite for smaller insects; in feeding on angle-worms the robin destroys a staunch human ally, an untiring tiller of the soil. These examples include three popular birds ignorantly valued for their supposedly good habits of destroying unpopular organisms of low type.

If we were strictly fair in the matter, we might regard some of our popular birds as harmful and worthy of no protection. Yet because of their great esthetic value, we do not so regard them. We protect them because we recognize their beauty of song and plumage, or their confiding ways, as of value to the human race. It is impossible to correctly estimate such values as this, due to their intangible qualities, but we recognize their existence nevertheless.

Certain valuable groups of birds, like the beneficial spiders, dragonflies and angle-worms, happen not to be popular, and we therefore welcome incriminating evidence against them, or seek excuses for offering them no protection. Thus are hawks and owls, generally speaking, regarded as undesirable bird neighbors, and the economic value and great beauty of these birds is scarcely at all recognized.

Everyone senses the beauty of the cardinal's flashing plumage; is it not strange that the graceful soaring of a red-tailed hawk is not so universally admired? The song of a goldfinch wins praise, while the distant hooting of a barred owl is considered ominous, unpleasant. No naturalist can understand such a limited appreciation. To the naturalist it is evident that the bright orange of a Baltimore oriole's breast and the subtle barring on a hawk's wing are essentially the same; and the song of a vesper sparrow and the scream of a red-tailed hawk are music alike to his ears.

We must admit that certain of the hawks and owls are destructive birds, of no economic value; but we have seen that some of our popular birds also have destructive habits. Can we not be fair to both groups, recognizing that their esthetic value may be sufficiently great to outweigh any minor economic losses we may sustain as a result of their presence? Such an attitude will insure for our posterity the presence of all species of birds which Pennsylvania now possesses; if we do not awaken to the esthetic value of our birds, some species will be gone forever.

Pennsylvania now protects the raven. This rare bird, which has been immortalized by the poet Poe, still occurs in limited numbers in our State. The writer feels that the protection of the raven, which is destructive rather than beneficial, is evidence that we are awakening to a proper appreciation of the esthetic value of at least some of our native birds.

REPORT OF THE SECOND ANNUAL MEETING OF THE PENNSYLVANIA ACADEMY OF SCIENCE, HARRISBURG, APRIL 2 AND 3, 1926

The President, Dr. Benj. L. Miller, presented his presidential address, using as his theme "The Origin and Utilization of the Cambro-Ordovician Limestones of Pennsylvania," after which the following papers were presented:

Pennsylvania building stones: R. W. Stone.
The Ionics of a Coolidge X-ray Tube: Marsh W. White, H. L. Yengley and A. M. Rothrock.
A chemically active modification of nitrogen: Gerald Wendt.
Aphids attended by ants in Pennsylvania: T. L. Guyton.
Notes on the Amphibia of Pennsylvania: N. H. Stewart.
A method of teaching comparative osteology: Louise Curtiss.
The range-limits and migrations of certain plants in Western Pennsylvania: O. E. Jennings.
Color-pattern regulation in the vermillion spotted newt (*Triturus viridescens*): H. H. Collins and C. F. Fencil.
Regeneration of the integuments in the vermilion spotted newt (*Triturus viridescens*): Miss Bessie Dickinson.
Absorption hairs of the peanut (*Arachis hypogea*): R. A. Waldron.
Morphology of the American dog tick: Geo. Zebrowski.
The evolutes of the parabola: Joseph B. Reynolds.
The relation of the Japanese beetle in spreading the brown rot of peaches: Geo. W. Martin.
Forest increment in Pennsylvania: E. A. Ziegler.
Why does the apple fall?: R. N. Davis.
Cosmic radiations. (By title only.) Richard Hamer.

The following committees were appointed:

Nominating committee: E. M. Gress, chairman, O. E. Jennings, Geo. H. Ashley.

Auditing committee: Marsh W. White, chairman, Jos. B. Reynolds.

Resolutions committee: R. N. Davis, chairman, Geo. Zebrowski, R. W. Waldron.

In the report of the Publication Committee it was pointed out that the Academy did not have enough money to publish the papers which had been given before the Academy. The Treasurer reported that with the incoming dues it seemed like the Academy would have $600.00 which might be used in the publication of the "Proceedings." Upon motion it was authorized that this committee be instructed to expend up to

$600.00 and publish the papers either in abstract, or in their entirety up to and including the present meeting. The Auditing Committee reported the books of the Treasurer of the Academy had been examined and found to be correct.

The Resolutions Committee presented the following resolutions:

1. *Resolved,* that the thanks of the Academy are extended to the local committee which made such thorough preparation for the meeting.

2. *Resolved,* that we hereby thank the Department of Property and Supplies for the use of the Senate Caucus Room which so admirably answers our purposes as a meeting place.

3. *Resolved,* that the various speakers on the program are commended for their efforts in making it a success, and also the members who have attended the meeting, some at a considerable sacrifice.

R. N. Davis,
R. A. Waldron,
Geo. Zebrowski.

The Membership Committee recommended for active membership the persons whose names follow. All were elected.

MEMBERS ELECTED APRIL 19, 1926

Austin, Paul R., Bucknell University, Lewisburg.
Barnes, Parker T., 1808 Finance Bldg., Philadelphia.
Cary, Benjamin F., Blossburg, Tioga Co.
Collins, H. H., M.D., Assoc. Prof. Zoology, University of Pittsburgh, Pittsburgh.
Croft, L. E., Watsontown.
Darlington, Rev. James H., 321 N. Front St., Harrisburg.
DeWitt, Iva I., 1041 E. Chestnut St., Sunbury.
Engle, J. Harold, Juniata College, Huntingdon.
Hartman, Phil. H., 212 W. Second St., Erie.
Horst, Miles, 309 Telegraph Bldg., Harrisburg.
James, Dr. Alfred P., History Dept., University of Pittsburgh, Pittsburgh.
Keyser, Walter L., Montoursville, R. D. 2.
Koenig, Paul L., 2212 Market St., Camp Hill.
Kuhn, Uhl R., 501 E. Liberty St., Chambersburg.
Light, Ray H., Cornwall.
Manley, Mrs. Beula, 730 Pearl St., Williamsport.
Miller, L. Paul, Central High School, Scranton.
Moser, G. Paul, Muir, Schuylkill Co.
Park, J. Theodore, Selinsgrove.
Pearson, Robert, 2313 N. Second St., Harrisburg.
Phillips, J. Charles, 24 S. Atherton Ave., Kingston.
Ray, Mrs. Geo. S., 153 W. 8th St., Erie.
Ray, Geo. S., M.D., 153 W. 8th St., Erie.
Reinert, Fred. I., 50 E. 4th St., Bloomsburg.
Reiter, Frank H., Dept. Public Instruction, Harrisburg.
Reiter, Geo. F., Bellefonte.

Reno, Margarida F., Woman's College, Bucknell University, Lewisburg.
Roberts, Miss Marjory, High School for Girls, 17th & Spring Garden St., Philadelphia.
Ross, Hillis T., 32 S. Second St., Lewisburg.
Rothrock, Addison M., Physics Bldg., State College.
Smith, John Hays, Camp Hill.
Snyder, Richard H., 116 E. Main St., Annville.
Stanford, Richard W., Harrisburg, R. D. 5.
Strait, Geo. B., Mansfield.
Taylor, Dr. J. S., Mathematics Dept., Univ. of Pittsburgh, Pittsburgh.
Tewksbury, Russell B., State Health Dept.
Thomas, Howard F. C., Box 34, Bellefonte.
Tinkham, Ruth P., Lititz.
Wilson, Lillian M., Bucknell University, Lewisburg.
Yeagley, Henry L., Physics Bldg., State College.
Zimmerman, J. A. Ernest, 132 E. King St., Shippensburg.

The Nominating Committee presented the following names for the offices of the following year:

President, N. H. Stewart, Bucknell University, Lewisburg.
Vice-President, E. A. Ziegler, Penna. Forest School, Mont Alto.
Secretary, T. L. Guyton, Penna. Dept. of Agriculture, Harrisburg.
Asst. Secretary, M. W. Eddy, Dickinson College, Carlisle.
Treasurer, H. W. Thurston, Penna. State College.
Editor, R. W. Stone, Penna. Geological Survey.
Executive Committee, W. A. McCubbin, State Dept. of Agriculture.

Upon motion the Secretary was instructed to cast a ballot in favor of each candidate.

At the evening meeting of the Academy Dr. Alexander Silverman gave a most interesting, popular lecture on "Glass" which was very much appreciated by the members of the Academy, and a vote of thanks was given to Dr. Silverman for his kindness in addressing the body. The Executive Committee was empowered to fix the time and place of the next meeting. An invitation was received from Dr. Norman Stewart to visit the Kitchen Creek district in Luzerne County on a summer field trip.

THE ORIGIN AND UTILIZATION OF THE CAMBRO-ORDOVICIAN LIMESTONES OF PENNSYLVANIA

(Presidential Address)

By Benjamin L. Miller

Introduction

The limestones of Pennsylvania have long been important assets of the State and each year are becoming even more valuable. In the early development of the Appalachian regions they were of service to the settlers in a secondary manner mainly. Due to their ready solubility in comparison with the other associated rocks they were responsible for many of the extensive valleys which were first settled because of the fertility of the soil, resulting from the decomposition of the limestones, and the ease with which it could be quickly brought under cultivation.

As soon as the frontiers had been pushed westward from the Philadelphia region, rapid progress was made in the development of the great fertile limestone valleys of what are now included in the counties of Chester, Lancaster, York, Adams, Northampton, Lehigh, Berks, Lebanon, Dauphin, Cumberland and Franklin. The next advance westward across the mountain ridges brought the pioneers to the equally broad fertile limestone valleys of Clinton, Centre, Mifflin, Huntington, Blair and Bedford counties. Very early in the history of the State these valleys, underlain by limestones of Cambro-Ordovician age, contained most of the agricultural inhabitants.

Not only have the Cambro-Ordovician limestones of Pennsylvania been responsible for the development of valleys, but due to their much greater thickness and complexity of folding in comparison with the limestones of other geologic periods they have resulted in the formation of much broader valleys.

In a few sections, these valleys, now so thickly populated, were settled slowly because the people found difficulty in securing supplies of water. Even at the present time, with perfected methods of deep drilling, some of the farmers in our limestone sections must depend on cistern water and in periods of drought are compelled to haul water from distant streams.

The limestone valleys with their relatively flat bottoms aided in the solution of the transportation problems. Roads could be built in every direction with ease, whereas in other sections the highways had to follow the larger streams closely or climb steep slopes. With the advent of the railroads they, too, experienced little difficulty in establishing easy grades in the limestone valleys and have used them so far as other conditions would permit. Towns were built there and these centers of population, excluding the anthracite mining towns and Philadelphia and vicinity, are the most important in the region lying east and southeast of the Allegheny Front.

With the development of coal mining, Pennsylvania passed gradually from an agricultural to a manufacturing State. In this change the limestones have acquired new importance. The early settlers quarried them locally to burn for agricultural lime and to build their houses but there was no reason for large quarries. Of course the absence of railroads or readily navigable streams would have prevented the building up of any large industry in any one section. However there was not sufficient demand. Lime for building and for the soils was needed in limited quantities, and as for building stones the State has better material in several sections than can be found in the limestones of the Cambro-Ordovician. In general this is true, although, in a few restricted sections, some unusually fine marble and limestone for structural purposes has been obtained, such as the material long quarried at Marble Hall, a short distance northwest of Philadelphia.

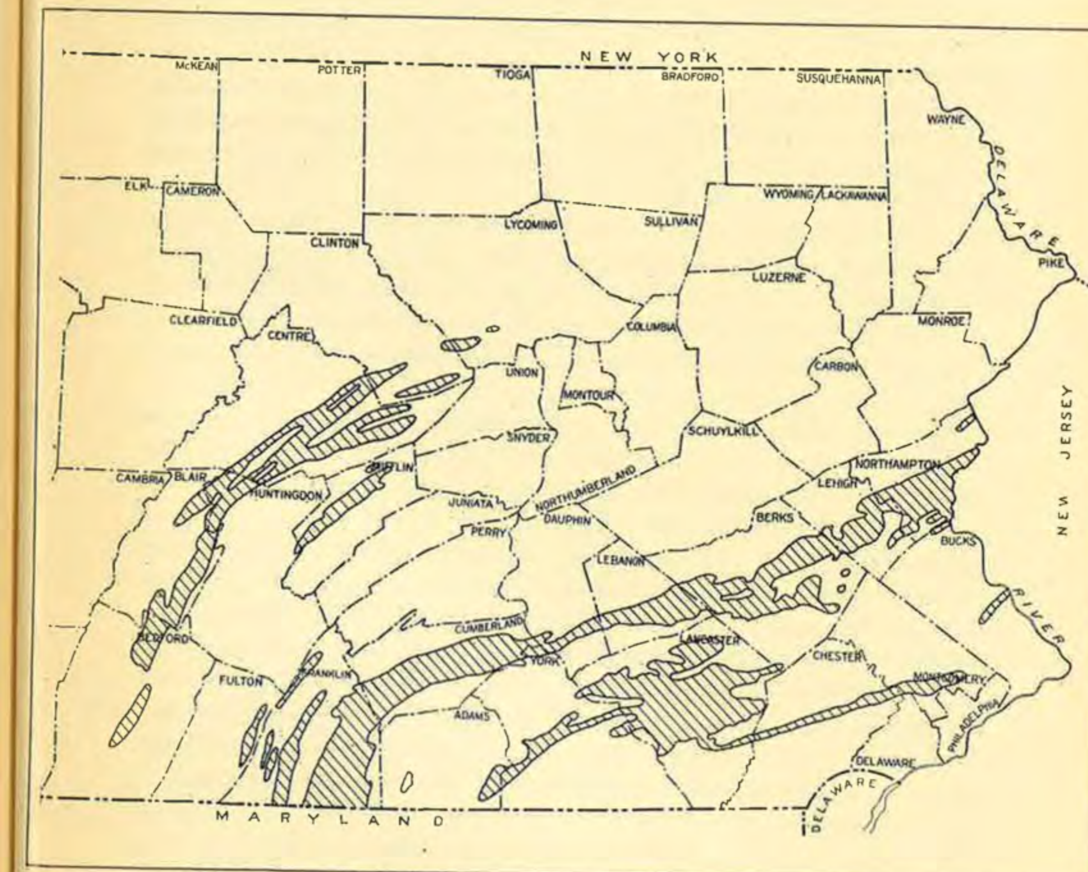
The full utilization of the Pennsylvania limestones was only brought about as manufacturing industries requiring the use of limestone were developed. These have become so diverse that one can scarcely enumerate them and they seem to be continually on the increase. The Cambro-Ordovician limestones have in recent years become a valuable asset in the supply of an important raw product needed in the manufacture of a variety of products.

The variability in these limestones has been of extreme value inasmuch as each use is apt to demand a certain quality of stone. To account for the variety and characteristics of these limestones it is well for us to consider the conditions existing during the time of their formation.

Cambrian Deposition

Our knowledge of the distribution of land and sea in the Appalachian region during the early Paleozoic era has been obtained by investigations of many geologists during the last eighty years. It seems certain that there was a rather large land mass that extended in a direction parallel to the present coast line, occupying at least a part, if not all, of the Atlantic coastal plain and Piedmont plateau as well as part of the submerged continental shelf. This land mass was bordered on the southeast by the deep Atlantic Ocean and on the northwest by a broad, shallow sea. All except the extreme southeastern portion of Pennsylvania ap-

PLATE X



Map of eastern Pennsylvania showing distribution of Cambro-Ordovician limestones.

pears to have been covered by this sea at the time of the greatest submergence. Oscillations of the land and sea occurred from time to time but at no time did the sea entirely disappear nor has any evidence been presented to show that it was very deep at any time.

Into this sea, pebbles, sand, and silt in suspension and various materials in solution were carried by streams from the adjacent land mass. The suspended matter was deposited mainly near the shore but occasionally distributed over wide areas by sea currents, whereas the matter in solution was distributed throughout the entire sea. Altogether there was a surprisingly small amount of terrigenous material deposited in the Appalachian Sea, which leads one to believe that the land was not much above the sea and hence furnished little material to the probable sluggish streams.

At the beginning of the Cambrian when this great inland sea came into existence considerable sand and, locally, pebbles and mud were deposited near the shore. These deposits are known in different parts of the State as the Chickies, Hardyston, Hellam, Weverton, Harpers and Antietam formations and consist mainly of sandstones or quartzites but locally of phyllites and conglomerates.

However, after a time the land ceased to furnish to the streams material in suspension to any appreciable extent and the sea water became clear. The supply of dissolved material brought in was extremely great and puzzles us to account for its source. Calcium and magnesium compounds were very abundant and furnish evidence that still earlier limestones and dolomites were being dissolved in the ancient land area.

If the calcium and magnesium were all derived from decaying crystalline rocks the supply of soluble material would have been checked by the extensive surface accumulation of insoluble materials long before enough materials had been carried off to form our great mass of Cambro-Ordovician limestones. The crystalline rocks furnish only a small percentage of soluble matter in proportion to the insoluble debris and the latter not being carried into the sea probably remained *in situ*. Ordinarily little soluble matter is supplied to the streams except by surface and shallow waters, thus leading to the conclusion that extensive pre-Cambrian limestones and dolomites existed, although rather uncommon in our present strata of this age in the Piedmont plateau. In Canada, however, the pre-Cambrian limestones of the Grenville formation are very thick and widespread.

While the source of the soluble carbonates is conjectural we can form a rather definite picture of the situation existing. The shallowness of the sea is proved by the numerous wave and ripple marks of the limestones, the oölites, and edgewise conglomerates, and the occasional exposure of the calcareous oozes to the drying action of the sun, as evidenced by the abundant sun or mud cracks.

In this shallow sea some agencies were at work resulting in the deposition of the dissolved carbonates. The idea that prevailed some years ago was that limestones were mainly formed of the calcareous skeletons of marine organisms, most of which were animals. That the Cambro-Ordovician limestones of Pennsylvania are not constituted of animal remains is shown by the surprisingly few fossils that they contain, far less than limestones of similar age in other portions of the country. This leads us to seek another cause for the precipitation of the soluble matter.

Some geologists have argued for chemical precipitation and it is not improbable that this was in part responsible. Evaporation of the water in local pools to the point of deposition of calcium and magnesium carbonates, if not to dryness, probably resulted locally since we find mud cracks so commonly. It is doubtful, however, whether this was the primary cause of deposition. No traces of the former existence of the end products of evaporation, gypsum and salt, have been found in the limestones. Also if the water had become sufficiently concentrated to deposit calcareous salts it is doubtful whether many organisms could have lived in it. Although, as said before, fossils are very rare, they do exist and represent a wide range of forms.

The explanation that appeals most strongly to the writer in accounting for the major portion of the deposition of these limestones is the agency of marine algae and bacteria. Investigations by our students of marine life within recent years have convinced us that these low forms of plant life are of great importance in the shallow tropical and subtropical ocean waters. Most of them leave no trace of their former existence in the deposits resulting from their action, and especially in the older limestones is such evidence completely lacking. One variety of algae is locally abundant in the upper Cambrian deposits. This is the *Cryptozoon proliferum*. J. P. Lesley, former State geologist, did not recognize these colonial forms as organic and described them as follows: "A very strange, peculiar and entirely mysterious feature of some beds is a structure resembling a mass of clam shells closely packed together with their rounded sides uppermost."

During the entire Cambrian period of calcareous deposition both calcium and magnesium carbonates were forming. In places these limestones contain only a few per cent. of magnesium carbonate but no instance occurs to the writer where its presence is not readily determined by chemical analysis. In many of the limestones the percentage approaches the theoretical composition of dolomite, 45.61, and a few analyses that seem to be reliable show even more than this. In general the Cambrian limestones of Pennsylvania contain from 15 to 30 per cent magnesium carbonate. They show wide variation within the same section and considerable difference even within the same stratum.

It is scarcely the place to discuss the much disputed and long debated question of the formation of dolomite. Few other geologic matters have received equal attention from geologists and chemists, and wide diversity of opinion still exists. The writer inclines to the view, which seems to be supported by field evidence within the State, that dolomitization has taken place in a variety of ways but that the most common method by which the dolomitic limestones of Pennsylvania have been formed has been by the secondary replacement of calcareous deposits while they still existed in the ooze condition. The sea water probably contained more magnesium carbonate than now exists in normal ocean water, as the water was shallow, evaporation consequently was relatively more effective, and the marine plants were removing the calcium carbonate in larger amounts.

In different parts of the State the Cambrian limestones have been determined to aggregate 3,000 to 6,500 feet. Many millions of years were required for the formation of such a thickness of these slowly-formed rocks.

Ordovician Deposition

There was no marked change in the Appalachian region by which the Cambrian period closed and the Ordovician began, and, in many places where fossils are rare, it is difficult to draw the exact line of separation. Soon, however, a change took place in the character of the deposits. Instead of a series of medium to high magnesian limestones, there were laid down at various times some very low magnesian limestones, low enough in magnesium carbonate to permit their use for purposes in which this substance is decidedly detrimental. Although with many more or less local alternations, there was a gradual progressive change to the formation of less highly magnesian limestones. Fossil shells of brachiopods, mollusca and other groups also became more abundant in the lower strata of the Ordovician which are included in the Beekmantown formation in most classifications. This formation varies in thickness from 1,000 to over 3,000 feet in various parts of the State.

The next change was more pronounced and during this shorter period throughout most of the State calcareous deposits with a minimum percentage of magnesium carbonate and with a gradually increasing mud content were laid down in many places although in certain localities no trace of this series of beds has been found. These beds known by various names in different districts vary from 500 to about 1,000 feet. They contain in several regions the most valuable and most useful stones for present existing industries, as will be described later.

Limestone deposition was terminated in the upper Ordovician period by the influx of great amounts of mud. In other words, the formation of limestone ended for the time and shales were found. The Cambro-Ordovician limestone-forming epoch terminated and millions of years elapsed before conditions again became favorable for the extensive deposition of calcareous sediments in the Appalachian region, and at no later period were limestones of equal thickness and extent formed.

Post Ordovician Events

Most of the subsequent geologic changes in the Pennsylvanian region have little connection with the subject of this address. A few, however, need to be mentioned. During the formation of the thousands of feet of limestone, the floor on which the sediments were being deposited gradually sank beneath the weight of the accumulating load. Several thousand feet of other sediments were laid down on top of the limestones and twice there were great crustal disturbances by which the originally horizontal beds were thrown into folds and displaced by faults. The first of these movements which came at the close of the Ordovician period has been called the Taconic Revolution and the second, at or near the close of the Carboniferous period, is known as the Appalachian Revolution.

These disturbances profoundly changed the physical character of the limestone sediments. The weight of the overlying sediments and the forcing of the calcareous strata downward into a more highly heated region, by themselves, would have resulted in the consolidation and cementation of the oozes, but the great compressive forces during the folding still further altered them. In general the stresses were greatest in the southeast and became progressively less toward the northwest. Closed and overturned folds and thrust faults occur all through the folded region but are more abundant in the southeastern districts.

Crystallization and the development of many new minerals by recombination of the chemical constituents present resulted where the compressive forces were sufficiently great and the other factors, such as heat and water, were active. The pure limestones of the Chester, Lancaster, and York valleys, as well as some other localities, were converted into medium to coarse grained marbles; the magnesian limestones were crystallized but never in coarsely granular marbles; and the limestones with impurities had many new minerals formed. In the Lehigh Valley region the argillaceous limestones developed great amounts of sericite mica which, in places, has produced slaty cleavage. The individual pieces of sericite there are very fine so that they can not readily be distinguished by the naked eye. On the other hand, in the Chester Valley where the compression was much more intense, similar original sediments were changed into decidedly micaceous limestones, the mica particles definitely arranged into bands.

The second important result of the folding is concerned with the present distribution of the outcropping limestone strata. Buried as they were by several thousand feet of other rocks they would have appeared at the surface only along the shore edges in narrow bands or by the removal of most of the overlying mass by erosion. The folding, by lifting the beds, assisted in the work of erosion which has now exposed the same limestone beds in many places. The numerous and repeated exposures of these limestones in various limestone valleys is due to these disturbances. They underlie that portion of the State west and northwest of the Allegheny Front, but, as gentle folding alone has taken place there, these limestones have not been sufficiently elevated to permit erosion to uncover them. As erosion practically ceases when a region is worn down to sea level and these limestones in that section are far below the level of the sea they can not even be uncovered by erosion until there has first been a great uplift of the region.

Utilization of the Pennsylvania Cambro-Ordovician Limestones

Uses based on physical characteristics: To a considerable degree there is a very close relationship between the chemical and physical properties, as will be more fully described later. Disregarding this connection I wish to briefly describe the uses to which the Cambro-Ordovician limestones are suited on account of their physical characters.

The first use was for buildings, a use to which they are still put, but in decreasing amount. Limestones for building purposes should be regularly bedded and have few joints or cracks, and those regular. Irregular and uneven bedding and numerous joints with various directions have in most places rendered the Cambro-Ordovician limestones of Pennsylvania of minor value for structural purposes.

Since the recent extensive permanent road building program has been under way these limestones have been quarried in scores of places for road metal. They are also used as crushed stone in concrete structures of all kinds. For these purposes limestones are most commonly used, if obtainable, on account of the ease with which they can be crushed and also the binding properties of the rock powder resulting from the stone being ground under the road traffic.

Only the best of the limestones can meet the State Highway specifications for hardness and resistance to wear. In scores of places within the State, however, the siliceous and highly magnesian limestones of

Cambro-Ordovician age are entirely satisfactory and they have been extensively used locally and shipped to other portions of the State and to other States. The supply is almost unlimited.

In recent years there has been an increasing demand for inert mineral substances as fillers in the manufacture of various products. Pulverized limestone has been used extensively in this way, especially in asphalt paving mixtures. Limestone free from quartz or chert is desired on account of the increased cost of grinding these hard substances.

Uses based on chemical characteristics: The present industrial demand for limestones is a product of rather recent development. Limestone, or products made from limestone, enter into the manufacture of so many articles that it is not possible to consider even briefly more than a small number.

In general the demands are for the following classes of stone:

1. High calcium limestones containing a minimum of other constituents.

These are most valuable for the production of high grade lime required in the manufacture of various chemical products. There is also a demand for this variety of stone in the manufacture of special kinds of cement and for use in the manufacture of ordinary Portland cement, where the bulk of the stone used is too low in lime and must be brought up to the required percentage by the addition of pure limestone. The two important regions within the State where stone of this kind is extensively quarried are in the Nittany Valley, near Bellefonte, and in the Lebanon Valley. In both places it is a part of the upper Ordovician limestones. The State's supply of this stone is limited and the demand is increasing.

2. Low silica limestones, preferably low in magnesium carbonate.

This type of limestone is in demand for flux. The lower the silica content the better. Many fluxing limestones of poor quality are utilized because in many instances it pays to use poorer grade material close at hand, and hence cheaper, than to ship in better stone.

This same type of limestone has long been used for the manufacture of lime for agricultural and other ordinary purposes. This variety of stone has been quarried in almost every place where the Cambro-Ordovician limestones are present.

3. High magnesian limestones (dolomites), low in silica.

A recent industry has developed in Pennsylvania in which magnesia is separated from our dolomites containing more than 40 per cent magnesium carbonate. So far only Cambrian dolomites of the Chester Valley, in the vicinity of Conshohocken, Norristown and Valley Forge, have been used for this purpose.

The same type of magnesium limestones, but in which there is not as firm insistence on the actual amount of magnesium carbonate, is used in the open hearth steel furnace. Stone for this purpose is present in Lancaster and York counties.

4. Argillaceous limestones, low in magnesium carbonate.

These are the limestones so extensively utilized in the Lehigh Valley in the manufacture of Portland cement. Several companies in that district have quarries in which the stone has almost the exact chemical composition for making standard Portland cement. Others must add high-grade limestone brought from other sections. This type stone is not widespread within the State but is ample within the Lehigh Valley to supply the present mills for a hundred years or more.

Other divisions of limestones, containing definite limits of the various constituents, all needed for particular purposes, need not be mentioned in this address. The types described illustrate the varied character of the Cambro-Ordovician limestones and the purposes for which they are especially adapted.

Prospecting for Various Types of Limestone

As the chemical analysis of limestone is expensive and requires time, attempts have been made to locate stone of the required kind with a minimum of chemical analyses. Considerable progress has been made, although most geologists feel that they must check their field determinations by occasional analyses.

Our knowledge of the geographic and geologic distribution of various kinds of strata as explained under "Origin" is first used. We do not seek argillaceous or low magnesian limestones among the Cambrian rocks nor high magnesian beds in the upper Ordovician series. Some types however, have a rather wide distribution so that it is well to search throughout the limestone areas for them.

The argillaceous limestones are readily recognized by their dark color when not strongly metamorphosed or by the abundance of mica where they have been subjected to great compression and resultant breaking.

The low magnesian limestones are soft and easily broken in comparison with the highly dolomitic ones, so that a geologist can with practice rather closely approximate the magnesian content by the hardness and toughness of the stone when struck with the hammer. The magnesian stones are also finer grained and more compact than the less dolomitic ones of the same region. A slightly buff or cream color is also common among the dolomitic varieties.

When weathered surfaces are available the distinctions between high and low magnesian limestones can readily be made. The latter contain numerous straight cracks running in all directions, along which vein material has commonly been deposited in layers so extremely thin that the freshly broken surface scarcely indicates their existence. On being exposed to the weathering agents these cracks furnish access to dissolving fluids and the weathered surface of the rock looks as though some one had hacked the stone with a steel cutting implement.

The dolomitic limestones likewise have many more gash veins of quartz and calcite than do the purer limestones. There is also a greater amount of quartz in the vein fillings of the dolomites.

Where weathering has progressed downward to considerable depth the dolomites in various places appear to be shattered as though by a blast of dynamite. One quarry near Lancaster in the highly dolomitic limestone region was, at one time, worked for road metal by means of a steam shovel without any blasting.

The highest grade limestones, composed almost entirely of calcium carbonate, can be located in certain regions by sink holes and caves due to their ready solubility. In such instances outcrops are apt to be few.

All of these short cuts to the determination of the chemical composition of limestones by means of physical characteristics are useful, but must be used with care, as the most expert geologists in this line occasionally go astray, especially on entering a new region.

Conclusions

The Cambro-Ordovician limestones of Pennsylvania have long been recognized as a valuable asset to the State but their value is continually on the increase as the State continues to develop industrially. Although we have accumulated a great deal of useful information concerning them, much more is desirable. In this investigation the State can scarcely be expected to bear the expense, as the cost of minute field work and of hundreds or thousands of chemical analyses is almost prohibitive. Industrial concerns who require definite types of limestone in particular districts are taking the lead in these detailed investigations. The work of the geologists is to collect and preserve this information as it is furnished by the companies and made available for public use. Most of the firms using Pennsylvania limestones have been generous in supplying the much needed data.

ABSTRACTS OF PAPERS READ BEFORE THE ACADEMY OF SCIENCE, APRIL 2-3, 1926

PENNSYLVANIA BUILDING STONE

By R. W. Stone

Pennsylvania produces several kinds of building stone, all of which have proven their durability by use. Houses built of native stone a century ago are evidence in many parts of the State that any of these stones will last for hundreds of years. Granite gneiss has been quarried near Media since 1785 and a house built of this stone at Leiperville in that year shows no deterioration of the granite. Mica schist is quarried extensively in the Philadelphia district. The Bryn Mawr College buildings are a good example of its use. Radnor Friends' Meeting House, built of schist in 1718, is still in use and the stone in good condition.

Trap, or so-called black granite, quarried at several places in the eastern end of the State is imperishable but makes a very somber-colored building.

Granite is quarried at Seisholtzville and makes a very attractive pink building stone of great durability. Several churches in Allentown, Bethlehem, Reading, Sunbury, Harrisburg and other eastern cities are excellent examples of its use.

Limestone houses are common in the limestone valleys and many of them show no deterioration of the stone after a century and a half.

Brownstone from Hummelstown and other quarries in the Triassic belt is thought by some to be too soft to stand exposure long but the Mordecai Lincoln house, near Birdsboro, built in 1733, Boone house, 1730, and old Swede house, built in 1716, speak for its durability.

Marble formerly quarried at King of Prussia and used extensively in Philadelphia is but little used now, and slate in the Bangor, Slatington and Delta areas has been little in demand as a building stone, although it is abundant and durable. The color and difficulty of dressing are against it.

Sandstone occurs in all the State from Delaware Water Gap and Harrisburg to the western boundary and has been used successfully in important railroad bridges, abutments, tunnel facings, and in many houses, particularly throughout the country districts. The sandstone varies from very hard and light gray to soft and greenish, and all of it has lasting qualities.

THE "IONICS" OF THE COOLIDGE X-RAY TUBE

By Marsh W. White, H. L. Yeagley and A. M. Rothrock
Physics Department, The Pennsylvania State College

The invention of the now universally used Coolidge X-ray tube has been hailed as an event which was to put an end to all of the temperamental qualities of the older type of so-called "gas" tube. One of the major differences in the two types of tubes is the fact that in the "gas" tube the action of positive gas ions plays a most important part, whereas it has always been supposed that their effect in the "gas-free" Coolidge tube is entirely negligible. It is the purpose of this paper to show that this is not necessarily true. Experiments made with various Coolidge tubes of different designs have all shown the presence of sharp breaks in the current-voltage curves when the tubes were operated at constant filament temperatures. These breaks are ascribed to the action of positive ions, probably liberated by the action of electrons "reflected" from the target of the tube.[1] Such ions cause a neutralization of the negative space charge near the cathode. This gives rise to the sudden increases of current noted in the experiments, ranging from 100 to 400 per cent for different filament temperatures. The breaks in the current-voltage curves appear at about 2,000 volts for tubes with both molybdenum and tungsten water-cooled anodes. The breaks for a "universal" tube appear at a potential difference of about 6,000 volts. As the voltage is gradually reduced below these "break-down potentials," the current does not drop suddenly at the breakdown voltage, but falls off rather slowly as the voltage is lowered, until a potential difference of about 300 volts is reached, when the current suddenly drops again to the value which it had on the curve of increasing voltage. It is a significant fact that this voltage is about the value for the maximum efficiency of ionization of gases.

A CHEMICALLY ACTIVE MODIFICATION OF NITROGEN

By Gerald Wendt
Pennsylvania State College

(Abstract not received.)

[1] Ham and White, *Physical Review*, Vol. 27, p. 111 (1926); also Vol. 27, p. 510 (1926).

APHIDS ATTENDED BY ANTS IN PENNSYLVANIA

By T. L. Guyton
Penna. Department of Agriculture, Bureau of Plant Industry

It has long been known that species of the Family Aphididae are cared for by certain ant species. In fact, the story of ants and their aphid "cows" has almost become classic. In a study of the aphids of Pennsylvania the writer has made numerous collections from time to time, and in making these collections has taken the ants which were found attending the particular species of aphid. These ants were killed, mounted on pin-points, and were given numbers which corresponded to the number of the aphids which were collected. This collection has extended from 1918 up to 1925. In this time nineteen species of ants have been collected and thirty species of aphids have been recorded as being attended by ants. Appended to this paper is a list of the ants together with the aphids they were attending; also, a list of the aphids which were attended by ants.

Various relations were noted in the care given to the aphids by the ants. In certain groups the ants had construed covers over the aphid colonies. These covers were composed of bits of organic matter, especially leaves and stem, together with soil. These covers, of course, were on colonies above ground, and usually on colonies in close proximity to the ground. The greater number of colonies of aphids above ground attended by ants were in no way protected, excepting in a few such forms as the cherry aphis (*Myzus cerasi*), where the aphids themselves had formed gall-like coverings by the twisting of the leaves.

It has long been known that in some subterranean species the aphids are dependent upon the ants for their existence. This relation has been worked out for the corn root aphis (*Anuraphis maidi-radicis*). With this species the ants are constantly in attendance; even the eggs of the aphid are tended through the winter. Dispersal from plant to plant is for the most part by the ants actually carrying the aphids. It is believed that other species are also dependent upon ants for their dispersal from plant to plant. In a recent communication from a worker in Ohio a statement was made that the common root louse of lettuce (*Prociphilus erigeronensis*) is dependent upon ants for their dispersal, and probably the species is cared for throughout the entire life cycle. This species is frequently found in ant nests in the winter time. The writer in examining many hundreds of colonies of the peach root aphis (*Anuraphis persicae-niger*) has never found a colony which was not attended by ants, and it seems to be always the one species of ant in attendance. This

species is known as *Lasius niger* var. *neoniger*. The life history of this plant louse is not well understood, but it is the writer's belief that this species is another with a life cycle very closely tied up with that of the attending ant.

A List of Aphids Attended by Ants in Pennsylvania

Anoecia corni
Lachnus sp.
Trama troglodytes
Patchia virginiana
Chaitophorus quercicola
Chaitophorus viminalis
Neothomasia populicola
Melanoxantherum media
Mastopoda pteridis
Aphis asclepiadis
Aphis illinoisensis
Aphis urticaria
Aphis rumicis
Aphis cornifoliae
Aphis salicicola
Aphis cephalanthi
Aphis heraclella
Aphis vernoniae
Aphis epilobii
Aphis diervillacola
Aphis oenotherae
Aphis cornifoliae
Anuraphis maidi-radicis
Anuraphis middletonii
Anuraphis persicae-niger
Myzus cerasi
Myzus plantaginensis
Eriosoma americana
Prociphilus erigeronensis
Prociphilus alnifoliae

List of Ants Attending Aphids in Pennsylvania

Camponotus herculeanus ligniperdus var. *noveboracensis* Fitch.
Prociphilus alnifoliae, Hartstown, June 21.

Camponotus herculeanus sub. sp. *pennsylvanicus* DeGeer.
Chaitophorus viminalis, New Cumberland, July 5.
Aphis cornifoliae, Inglenook, May 31.
Lachnus sp., Loretto, August 25.

Camponotus herculeanus pennsylvanicus var. *ferrugineus* Fabr.
Chaitophorus quercicola, Bowmansdale, July 2.

Crematogaster lineolata Say.
Aphis cephalanthi, Harrisburg, June 19.
Aphis epilobii, New Bloomfield, July 12.

Crematogaster sp.
Myzus plantagineus, Bowmansdale, Sept. 18.

Crematogaster sp.
Mastopoda pteredis, Hunter's Run, Sept. 2.

Dolichoderus taschenbergi var. *atterimus* Whlr.
Aphis oenotherae, Hunters Run, Sept. 2.

Formica fusca var. *subsericea* Say.
Patchia virginiana, New Bloomfield, July 12.
Chaitoporus quercicola, Inglenook, July 1.
Myzus cerasi, Harrisburg, June 27.
Aphis spiraephila, Morrisville, July 8.
Aphis veroniae, Dromgold, August 17.
Neothomasia populicola, North East, July 20.
Anoecia corni, Harrisburg, October 23.
Aphis rumicis, Chambersburg, June 17.

Formica fusca var.
Prociphilus alnifoliae, Hartstown, June 21.

Formica sanguinea var. *subintegra* Emery.
Aphis urticaria, Manada Gap, August 31.

Formica truncicola subspecies *obscuriventris* Mayr.
Neothomasia populicola, Bowmansdale, June 29.

Lasius claviger Rogers.
Prociphilus erigeronensis, Chambersburg, September 10.

Lasius niger var. *americanus* Emery.
Myzus plantagineus, Bowmansdale, September 18.
Eriosoma americana, New Bloomfield, May 24.
Aphis heraclella, Harrisburg, September 5.
Aphis diervillacola, Inglenook, May 21.
Aphis rumicis, Harrisburg, September 14.
Aphis heraclella, Perry County, July 16.

Lasius niger var. *neoniger* Emery.
Anuraphis maidi-radicis, North East, July 19.
Aphis rumicis, Rockville, June 10.
Trama troglodytes, Camp Hill, September 19.
Aphis illinoisensis, Enterline, July 15.

Lasius latipes Walsh.
Prociphilus erigeronensis, Dauphin, April 27.

Lasius umbratus mixtus var. *aphidicola* Walsh.
Prociphilus erigeronensis, Inglenook, July 4.

Myrmica scabrinodis var.
Aphis oenotherae, Pine Grove Furnace, May 26.
Hysteroneura setariae, New Germantown, September 7.

Prenolepis imparis Say.
Aphis rumicis, Chambersburg, September 24.

These lists are not complete, but they are given with a hope that some interest may be aroused in this interesting relation of one insect to another. That this relation has an economic bearing is evidenced by the fact that in the corn belt of this country the matter of controlling the corn root aphis is very largely a matter of controlling the ant which attends it; and it may be that, when the relations of ants and certain of our aphid pests are better known, such control will be found practical.

The author is indebted to Mr. M. R. Smith, University of Illinois, for identification of the ants.

NOTES ON THE AMPHIBIA OF PENNSYLVANIA

By N. H. Stewart

(Abstract not submitted.)

A METHOD OF TEACHING COMPARATIVE OSTEOLOGY

By Louise Curtiss

(Abstract not submitted.)

THE RANGE-LIMITS AND MIGRATIONS OF CERTAIN PLANTS IN WESTERN PENNSYLVANIA

By O. E. Jennings
University of Pittsburgh

Since the retreat of the continental glacier, possibly 75,000 years ago, plants have been migrating northwards, although remaining behind in suitably colder habitats here and there, particularly on the higher plateaus and mountains of Pennsylvania. Different species move at different rates: small winged seeds (poplar, birch, pine) rapidly; large heavy seeds or fruits slowly (walnut, oak). Longer growing seasons prevail in southwestern Pennsylvania and along Lake Erie, relatively very short seasons on the high plateau in McKean and Potter counties along the northern middle border of the State. Papaw (*Asimina*) occurs half-way up the State from the south and also along Lake Erie; white oak has not yet capped the plateau dome of McKean and western Potter counties.

Notwithstanding the relation of plants to the ecological factors of the environment, there is in Pennsylvania evidence of migration still taking place following the retreat of the ice of Glacial Times, and emphasis should be placed on the importance of historical factors also. There is penetration of more northern vegetation by tongues of southern vegetation along lower valley soils, as, for instance, the persimmon along the Susquehanna valley. There is persistence of local areas of northern plants (sphagnum-tamarack bog flora); and the maps of distribution indicate entering wedges of the Ohio Valley flora into the southwestern part of Pennsylvania, apparently coinciding with areas of longer growing season and possibly indicating that these changes are due to a change of climate to drier warmer conditions, favoring the broadleaf deciduous forest of the interior at the expense of the coniferous forest of the northeast.

COLOR-PATTERN REGULATION IN THE VERMILION SPOTTED NEWT (*TRITURUS VIRIDESCENS*)

By H. H. Collins and C. F. Fencil

(Abstract not submitted.)

REGENERATION OF THE INTEGUMENT IN THE VERMILION SPOTTED NEWT

By Bessie Dickerson
University of Pittsburgh

The experiments and observations were made in an attempt to determine and describe the phenomena of regulation as manifested in the origin of the new tissue formed in the process of wound repair and to find out, if possible, the underlying factors which cause the epidermal cells to spread over a wound surface. The problem was studied both from an histological standpoint and from gross observations.

The following conclusions were reached:

1. The removal of integument in the vermilion-spotted newt is followed by a rapid movement of the epidermis over the denuded area. The dermis, while it is much slower in repair, is finally restored to the normal condition. The glands are also restored, but at a much later stage than the outer parts of the integument.

2. The stages in the healing of a wound are: (a) a sliding of the epidermal cells from the edge of the wound into the denuded area; and (b) epidermization or proliferation of these cells.

3. The epidermal cells around the edge of the wound seem to be pushed out over its surface by pressure exerted at some distance from the edge where there is proliferation of the cells by mitosis. There is no evidence of any cell division at the edge of the wound.

4. The melanophores for the formation of the new spots in the regenerated tissue come from the surrounding dermal spots and also from the peritoneal pigment.

5. It takes a period of about four months for an injury to the integument of an animal to be restored to the normal condition. This of course does not take into consideration the physical condition of the animals which affect the rate of growth of the new tissue.

6. The normal condition is finally attained when the yellow color appears in the integument and the spot pattern is reproduced.

ABSORPTION HAIRS OF THE PEANUT[1]

By R. A. Waldron
Dept. of Biology, Slippery Rock Normal School

The peanut plant, little known or grown in Pennsylvania (although there is a quick maturing variety which could be raised with profit), seems, upon investigation, to be one of the most interesting members of the plant world. It is not only a most valuable food plant for man, animals and plants themselves, but is most unusual in its structures and habits of growth. For example, after the outer flower parts drop it produces fruit—the so-called peanut—by pushing its central pistil, appearing like a small pointed stem, into the soil, and immediately the now tiny fruit appears as a peanut-shaped swelling at the tip; this now loses its outer skin (epidermis) in order that the subjacent tissue may produce an abundant mass of delicate hairs which are used as are normal root hairs for absorbing water and the soil food solutions. Many such fruits appear on a single plant and the absorbing ability of the fruits is such that the true roots may be severed and the plant as a whole continues growth. The young hair-covered fruits and their stems become the food assimilators. The stems bearing the peanuts are also hair-covered—*i.e.*, those parts which are beneath the soil, and it is thought that these also aid in assimilation.

Another interesting discovery is that, contrary to expectation (the peanut plant having been reported to have *no* root hairs) normal absorbing root hairs were found near the tips of young vigorous rootlets, under certain conditions. There were also found rosette-like whorls of hairs at the base of newly formed rootlets where these join the older roots.

It seems that nature has made abundant provision, in the case of the peanut, for absorption of water and food—this latter in water solution. If one set of hairs fails another is made available. The peanut loves a dry sandy soil and in order to obtain proper amounts of foods in such, an abundance of hairs, which increase absorbing surfaces, would seem essential for a plant such as this.

MORPHOLOGY OF THE AMERICAN DOG TICK

By Geo. Zebrowski
Villanova College

(Published in Transactions of the American Entomological Society, 1926, Vol. 51, pp. 331–369.)

[1] Waldron, R. A. The Peanut—Its History, Histology, Physiology and Utility. Contributions University of Pennsylvania, 1918. Pp. 301–338.

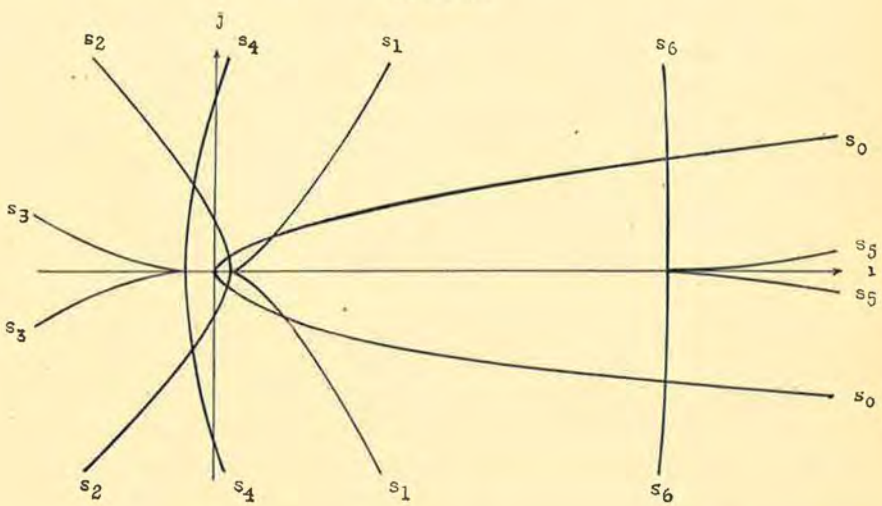
EVOLUTES OF THE PARABOLA

By Jos. B. Reynolds

It is the purpose of this paper to prove the following propositions concerning the parabola and its evolutes.

I. All evolutes of the parabola are symmetrical with respect to the axis of the parabola.
II. Every evolute of the parabola of odd order has one cusp only and it lies upon the axis of the parabola. Evolutes of even order have no cusps.
III. The curvature of the evolutes of the parabola at corresponding points decreases as the order of the evolutes increases.
IV. The curvature of each evolute is greatest where the evolute crosses the axis of the parabola.
V. Each evolute of the parabola of odd order has a point in common at its cusp with the evolute of next higher order at its vertex.
VI. The cusps on all evolutes of the parabola of order $4n+1$ lie within the parabola and those of order $4n-1$ lie without the parabola.
VII. The vertices of all evolutes of the parabola of order $4n+2$ lie within the parabola and those of order $4n$ lie without the parabola.
VIII. The vertices of the evolutes lie at increasingly greater distances from the vertex of the parabola.
IX. All evolutes of the parabola of odd order are concave towards the tangent at the vertex of the parabola.

Plate XI



X. Evolutes of the parabola of even order beginning with the second have concavity alternately opposite and in agreement with that of the parabola.

Let the equation of the parabola be

(1) $$r_0 = at^2 i + 2at\, j,$$

the vertex being origin, the axis of the parabola and tangent at the vertex being the i- and j-axes, respectively. Then a vector tangent to the parabola is $t\,i + j$ and a vector normal to the parabola is $i - t\,j$. Whence, if for a general evolute we write

(2) $$r_k = F_k\, i + G_k\, j \qquad k = 1, 3, 5, ---$$

the next following evolute r_{k+1} will be given by the envelope of the normal, n, to r_k or of

$$n = (F_k + st)i + (G_k + s)j.$$

For the envelope

$$dn/dt = (F_k' + s + t\, ds/dt)i(G_k' + ds/dt)j = 0$$

in which the primes indicate derivatives with respect to t. From this

$$s = tG_k' - F_k',$$

giving

(3) $$r_{k+1} = (F_k + G_k' t^2 - F_k' t)i + (G_k + G_k' t - F_k')j.$$

Since $F_k' t = - G_k'$

(4) $$r_{k+1} = [F_k - t(t^2+1)F_k']i + [G_k - (t^2+1)F_k']j = F_{k+1}i + G_{k+1}j.$$

The next following evolute will be given by the envelope of the normal, n_1, to r_{k+1} or of

$$n_1 = (F_{k+1} + s)i + (G_{k+1} - st)j$$

giving

(5) $$r_{k+2} = [F_k - 4t(t^2+1)F_k' - (t^2+1)^2 F_k'']i + [G_k - (1 - 2t^2 - 3t^4)F_k' + t(t^2+1)^2 F_k'']j.$$

Applying formulas (4) and (5) successively to (1) we find

$$r_1 = a(2+3t^2)i - 2at^3\, j$$
$$r_2 = a(2 - 3t^2 - 6t^4)i - 2at(3+4t^2)j$$
(6) $$r_3 = -a(4 + 33t^2 + 30t^4)i + 2at^3(11 + 12t^2)j$$
$$r_4 = a(4 - 33t^2 - 156t^4 - 120t^6)i + 2at(33 + 104t^2 + 72t^4)j$$
$$r_5 = a(62 + 723t^2 + 1500t^4 + 840t^6)i - 2at^3(241 + 600t^2 + 360t^4)j$$
$$r_6 = a(62 - 723t^2 - 5946t^4 - 10200t^6 - 5040t^8)i - 2at(723 + 3864t^2 + 6120t^4 + 2880t^6)j.$$

Using $s_k' = ds_k/dt = (dr_k/dt)_0$, the subscript zero indicating absolute value, we find for the derivatives of the arcs s_0, s_1, s_2, ---

$$ds_0/dt = 2a(1+t^2)^{\frac{1}{2}}$$
$$ds_1/dt = 6at(1+t^2)^{\frac{1}{2}}$$
$$ds_2/dt = 6a(1+4t^2)(1+t^2)^{\frac{1}{2}}$$
$$ds_3/dt = 6at(11+20t^2)(1+t^2)^{\frac{1}{2}}$$
$$ds_4/dt = 6a(11+104t^2+120t^4)(1+t^2)^{\frac{1}{2}}$$
$$ds_5/dt = 6at(241+1000t^2+840t^4)(1+t^2)^{\frac{1}{2}}$$
$$ds_6/dt = 6a(241+3964t^2+10200t^4+6720t^6)(1+t^2)^{\frac{1}{2}}.$$

Letting R_0, R_1, R_2, --- be radii of curvature for the parabola and its successive evolutes we find, since R_k is proportional to ds_k/dt

$$R_1 = 3tR_0$$
$$R_2 = 3(1+4t^2)R_0$$
(8) $$R_3 = 3t(11+20t^2)R_0$$
$$R_4 = 3(11+104t^2+120t^4)R_0$$
$$R_5 = 3t(241+1000t^2+840t^4)R_0$$
$$R_6 = 3(241+3964t^2+10200t^4+6720t^6)R_0.$$

Since R_0 is at no point zero R_{k+1} is at no point zero and has its least value at $t=0$, and has equal values for equal absolute values of t. Also, R_k is zero for $t=0$, but at no other place as revealed by lack of change of signs in the functions of t^2 in the parentheses.

From (4)

(9) $$r_k{}'_{+1} = -t[(t^2+1)F_k{}'' + 3tF_k{}']i - [3tF_k{}' + (t^2+1)F_k{}'']j$$

and from (5)

(10) $$r_k{}'_{+2} = -[3(1+t^2)F_k{}' + 8t(t^2+1)F_k{}'' + (t^2+1)^2F_k{}''']i + t[3(1+4t^2)F_k{}' + 8t(t^2+1)F_k{}'' + (t^2+1)^2F_k{}''']j.$$

Since F_1 contains only even powers of t, (4) and (5) show that F_k and F_{k+1} contain only even powers of t. Again since G_1 contains only odd powers of t, G_k and G_{k+1} contain only odd powers of t; therefore every evolute of the parabola is symmetrical with respect to the axis of the parabola.

By (9 and (10)

(11) $$s_k{}'_{+1} = [3tF' + (t^2+1)F''](1+t^2)^{\frac{1}{2}}$$
(12) $$s_k{}'_{+2} = [3(1+4t^2)F' + 8t(t^2+1)F_k{}'' + (t^2+1)^2F_k{}'''](1+t^2)^{\frac{1}{2}}.$$

An inspection of (9), (10), (11) and (12) shows that, since F_1 contains only even powers of t with positive derivatives, $s_k{}'_{+1}$ contains only even powers of t with real positive coefficients and cannot vanish for real values of t. Likewise $s_k{}'_{+2}$ contains only odd powers of t and must vanish for $t=0$, but for no other real value of t. Hence every evolute of the parabola of odd order has one cusp, only, and it lies upon the axis of the parabola and evolutes of even order have no cusps.

Again,

(13) $$R_{k+1} = [3tF_k{}' + (t^2+1)F_k{}'']R_0/2a$$

and

(14) $$R_{k+2} = [(1+4t^2)F_k{}' + 8t(1+t^2)F_k{}'' + (1+t^2)F_k{}''']R_0/2a.$$

If $F_k{}'$ is a rational integral algebraic function of odd powers of t with real positive coefficients the bracket in (13) is a rational integral algebraic function of even powers of t, with real positive coefficients and of a power one higher than $F_k{}'$, and the bracket in (14) is a rational integral function of odd powers of t and of a power two higher than $F_k{}'$, with real positive coefficients each of which is greater than the coefficient of the corresponding power of t in $F_k{}'$.

Since $F_1{}'$ is a rational integral algebraic function of odd powers of t with real positive coefficients F_3, F_5, ----- F_k are the same kind of functions with increasingly higher powers of t and larger corresponding coefficients. Hence the ratio

(15) $$R_{k+2}/R_k = 3(1+4t^2) + 8t(1+t^2)F_k{}''/F_k{}' + (1+t^2)F_k{}'''/F_k{}'$$

is an even function always greater than 3; that is, the curvature of succeeding odd evolutes decreases for a given value of t. In like manner one can prove the same true for even evolutes for $t^2 > 0$.

Since R_{k+1} is a function of t^2 with positive coefficients, and R_{k+2} is t times a function of t^2 with positive coefficients, each is evidently numerically greatest for $t=0$; showing that the curvature of each evolute is greatest where the evolute crosses the axis of the parabola.

Considering the equations:

$$r_k = F_k i + G_k j$$
$$r_{k+1} = [F_k - t(t^2+1)F_k{}']i + [G_k - (t^2+1)F_k{}']j,$$

since F_k contains only even powers of t and G_k only odd powers of t it follows that for $t=0$

$$r_k = F_k(0)i \qquad \text{and} \qquad r_{k+1} = F_k(0)i.$$

Therefore each evolute of the parabola of odd order has a point in common at its cusp with the evolute of next higher order at its vertex.

From equation (5)

(16) $$r_{k+2} = [F_k - 4t(1+t^2)F_k{}' - (t^2+1)^2F_k{}'']i + [G_k - (1-2t^2-3t^4)F_k{}' + t(t^2+1)^2F_k{}'']j = F_{k+2}i + G_{k+2}j$$

so that the cusp of the odd ordered evolute r_{k+2} is given by $t=0$ as

$$r_{k+2} = [F_k(0) - F_k{}''(0)]i.$$

It is necessary to determine the sign of the coefficient of i to locate the various cusps. From (16)

(17) $$F_{k+2} = F_k - F_k'' - 4F_k't^2 - 2F_k''t^2 - 4F_k't^3 - F_k''t^4.$$

If F_k is of the form

(18) $$F_k = A + A_2t^2 + A_4t^4 - - - - - - - - + A_{2n}t^{2n},$$

in which $A, A_2, A_4 - - - - - A_{2n}$ are all positive and each greater than the preceding one, then F_{k+2} is of the same form as (18) with all coefficients negative and each numerically greater than the preceding one. That is, since F_1 is of the form (18), we have for $t = 0$

$$F_{4n-1}(0) = F_{4n-3}(0) - F_4{''}_{n-3}(0), \text{ a negative coefficient,}$$
$$F_{4n+1}(0) = F_{4n-1}(0) - F_4{''}_{n-1}(0), \text{ a positive coefficient.}$$

Whence the cusps of all evolutes of the parabola of order $4n + 1$ lie within the parabola and those of order $4n - 1$ lie without the parabola. Since the vertices of the evolutes of order $4n + 2$ and $4n$ coincide with these cusps respectively the vertices of all evolutes of the parabola of order $4n + 2$ lie within the parabola and those of order $4n$ lie without the parabola. On account of the increasing size of the coefficients the vertices lie at increasingly greater distances from the vertex of the parabola.

To discuss the concavity of r_k we use

(19) $$d^2x/dy^2 = [G_k'F_k'' - F_k'G_k'']/(G_k')^3 = -1/t^3F_k',$$

the last form following from $G_k' = -F_k't$ and hence $G_k'' = -F_k' - F_k''t$. Since F_k is positive in all coefficients for $k = 4n + 1$ and negative for $k = 4n - 1$, it follows because d^2x/dy^2 is an even function of t that:

All evolutes of the parabola of odd order are concave towards the tangent at the vertex of the parabola.

In like manner for evolutes of even order

$$d^2x/dy^2 = 1/G_k{'}_{+1}.$$

If $k + 1$ is of the form $4n - 2$, G_k is a negative odd function of t and therefore $G_k{'}_{+1}$, a negative even function of t so that d^2x/dy^2 is negative; hence evolutes of the parabola of even order, $4n - 2$ have concavity opposite to that of the parabola. If $k + 1$ is of the form $4n$, G_{k+1} is a positive odd function of t and $G_k{'}_{+1}$ a positive even function of t, so that evolutes of the parabola of order $4n$ have concavity in agreement with that of the parabola. This completes the proof of the ten propositions on the evolutes of the parabola.

THE JAPANESE BEETLE AN AGENT IN SPREADING THE BROWN ROT OF PEACHES

By Geo. W. Martin
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Upon making over eighty experiments, chiefly with raspberries, blackberries, cherries, peaches and a few apples, in the summer of 1925 at the Japanese Beetle Laboratory, Riverton, N. J., the author proved beyond all doubt that the Japanese beetle furnishes sufficient evidence to show it to be a common carrier of the common disease known as brown rot among fruits, notably the peach. Other diseases than the brown rot are carried by this insect, since many experiments showed the presence of other spore-bearing fungi, such as the spores of alternaria, penicillium, rhizopus, gloeosporium, fusarium, as well as the yeasts, bacterias, etc.

From the many experiments performed, the author concluded that the fruits under experimentation, with the apple probably excepted, can become inoculated with the brown rot disease without any lesions occurring on the epidermis. When lesions are caused by the mechanics of insects, hail or otherwise, no doubt the inoculum gains headway much earlier and develops more rapidly toward complete infection and decay. But as far as the experimentation was extended with this particular beetle, the author inclines to the belief that the greatest factor in the distribution of spores is the wind.

FOREST INCREMENT IN PENNSYLVANIA

By E. A. Ziegler
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To intelligently consider a forest policy any nation or State must have some basic information on

(a) the quantity of timber and wood products consumed,
(b) the quantity grown in its forests, and
(c) the chance for permanent import if consumption exceeds growth.

We have relatively accurate data through our census of manufactures on the timber and wood consumption of the entire United States as well as our own State. A thorough canvass of the forest resources of Canada and other adjacent forested countries has convinced economists that the

United States can not secure any considerable qutntities of structural timbers, but only tropical furniture woods and a partial paper pulp wood supply from without. This pointed then definitely to a study of our own actual forest increment and its possible increase if found very deficient.

Sweden and Finland in recent years saw the vital need of such a study since their forest product exports form such a large part of their foreign trade and the perpetual maintenance of their forest production is necessary to their economic prosperity. These smaller nations therefore sent out timber survey crews, which measured narrow parallel strips through the timber lands from boundary to boundary, thereby securing accurate data for a fixed percentage of their forests,

(a) on forest area,
(b) on standing timber thereon,
(c) on rate of growth or increment.

The last was secured by measuring the number of years the timber required to grow an inch in diameter. These increment measurements were taken systematically by means of increment augurs which extract a small radial core from a growing tree and expose the width of the annual rings of wood to measurement. These studies show whether the national policy should be directed toward an increasing cut or a decreasing cut, or toward increasing a deficient increment in order to balance cut and growth or increment.

Although from general observation men interested in conservation were fully convinced that the United States was long cutting far more timber than it was growing, no attempt to reduce this serious situation to definite figures was made until the late B. E. Fernow published his Economics of Forestry in 1902. This writer quotes census data on forest area and cut of timber in certain forms only, but did not attempt to bring definite figures on total wood cut from the forest "face to face" with the annual growth of our forests.

Neither the United States nor Pennsylvania has ever attempted a systematic forest survey like that of Sweden or Finland. We have always depended on the census for forest areas and forest products cut, and on the compilation of somewhat fragmentary estimates for our standing timber resource. Little has been done toward a systematic increment study.

The writer assisted Mr. R. S. Kellogg in compiling the first definite statement of total wood cut from the forests in the United States. This was placed (in a table[1] published in 1909) at "over 20 billion cubic

[1] U. S. Forest Service, p. 14, Circular 166, 1909.

feet." Further canvasses and compilations have tended to increase this to 24 billion cubic feet. This total consumption estimate was seen to be only half of the picture, however.

About this time the U. S. Forest Service requested the writer to prepare a statement of forest growth for the United States for the First National Conservation Congress called by President Roosevelt. While it was realized such a statement could not be absolutely accurate, it could nevertheless show what data existed and arrive at an approximate idea of increment sufficiently accurate to set over against the total wood cut and to show whether forest conservation was as urgent as its proponents claimed.

The first step was to classify the total forest and brush land of the United States into:

1. Virgin timber, 188 million acres—no net increment.
2. Cut-over lands made practically non-productive by fire, 82 million acres. No increment could be assumed.
3. Cut-over lands restocking with a fair increment, 225 million acres.

This gave a total forest area of 495 million acres for the United States, which compares closely with the most recent figures[2] of 469 million acres total, and 250 million acres cut over and reproducing, and 81 million not restocking. The virgin forest since 1908 would necessarily show a decrease and the cut-over lands somewhat restocking, an increase.

By taking sample plot increment in the different forest regions for fully stocked measured plots, and reducing these increments by the same percentage that the actual second-growth forest represented as compared with the fully stocked sample plots, actual increment was approximated for this reduced area of growing forest. This calculation showed an average increment of 28 cubic feet of wood per acre and year on the 225 million acres of young growing forest or 13 cubic feet on each of the total 495 million acres of forest land, with a total increment of 6.7 billion cubic feet. The most recent estimate in The Forest Resources of the World (just quoted) puts the total forest increment for the United States at six billion cubic feet. That fifteen years of research should show present authorities still using the same methods of analysis and almost the same results seem to corroborate the approximate accuracy of the earlier data collected and the reasonableness of the assumptions where such were necessary to bridge the gap of missing field measurements. *In 1908 the big fact established was that forest consumption was outrunning forest growth as 20 to 6.7 or more.* This ratio is now claimed to be as

[2] Zon & Sparhawk, Forest Resources of the World, Vol. II, p. 530, 1923.

great as 24 to 6 or 4 to 1. Here then was the concretely expressed argument for an aggressive national forest policy, which is attempting to bring up the growth end of the ratio by encouraging private reforestation and public forest ownership. The consumption part of the ratio may be cut down by economies in utilizing wood, but the greatest effort should be made to bring up the increment end of the ratio. These two efforts should ultimately result in changing the disastrous ratio of 4 to 1 to about 4 to 4 when we will be self-sustaining in forest products. This means a reduction of 20 per cent in total wood cut and an increase of 230 per cent in increment, with the elimination of the huge fire loss.

How does this vital ratio of wood consumption and forest increment lie in Pennsylvania? Only one published attempt at portraying this in actual figures has been made to the writer's knowledge. Illick[3] gives as his conclusion without stating his data that the average annual growth per acre at present is .25 cord (stacked), which would be about 22 cubic feet (90 cubic feet solid per stacked cord) per acre on all classes of forest land. Although no absolute check can be made on this figure, it is probably as near the truth as can be hoped for until more of our forests are placed under management and an accurate stock taking and increment calculation completed. The figure is probably a little too high for the forests as they exist at present.

A recent systematic measurement of the 23,000 acres of second-growth forest attached to the State Forest School at Mont Alto showed a stock of 1,100 cubic feet per acre (including blighted chestnut), with an average age of 35 years, or a mean annual increment of 33 cubic feet. Excluding the chestnut this increment has fallen to 20 cubic feet. The increment in per cent of the growing stock is about 3 per cent, which is a little above an average rate for hardwood forest at 35 years, as shown by yield tables of oak and beech. As timber grows older and the growing stock increases in quantity this increment percentage falls, as is shown by the measurement of several 60-year-old fully stocked stands of second-growth hardwoods near Warren last summer. These stands showed 3,000 cubic feet of wood or an average annual increment of 50 cubic feet, or an increment per cent of only 1.7. For the present age of the young forests of the State 3 per cent increment is therefore felt conservative.

Illick estimates the forests of the State in their present depleted condition average 6.2 cords of wood per acre growing stock. Applying this 3 per cent increment would give .186 cords increment or only 17 cubic feet per acre instead of 22 cubic feet, as his increment figures show. For

[3] Illick, J. S. The Forest Situation in Pennsylvania. Penna. Dept. of Forests and Waters, Bulletin 30, pp. 7–10, 1923.

purpose of discussion 20 cubic feet increment may be safely taken as the present average increment of all our forest land in Pennsylvania.

A careful examination of Pennsylvania's cut of lumber, fuel wood, fencing, paper and chemical wood, and minor products will show approximately 700 million cubic feet of wood being cut in and out of Pennsylvania annually in all forms for our use. This represents a consumption of 54 cubic feet per acre of forest while we grow only 20. Our consumption-growth ratio is therefore 2.7 to 1.

This discussion shows that we in Pennsylvania must either

(1) develop our forest resources to the self-sustaining point, or

(2) develop a permanent source of import from without the State.

A careful examination shows that Pennsylvania imports large quantities of lumber from the Pacific Coast and the South, and pulp wood from Canada, at a great cost. This cost is placed as high as $100,000,000 annually. Even though we were willing to continue to neglect our forest production possibilities and pay out this large sum there is more than a serious doubt if this outside supply is permanent. Canada is placing obstacles in the way of exporting pulp wood in order to drive our paper mills into Canada. The entire nation is beginning to focus its lumber demands on the three northwestern lumber States. This means a multiplying of the mills in this last parcel of our virgin timber and a relative early adding of these States to the class of Pennsylvania, Michigan and Minnesota, which are now completely stripped of their heavy virgin timber. The South will be cut out on the holdings of 75 per cent of its lumber mills in ten years. We are rapidly nearing the point nationally where our second-growth forests must prove the salvation of our wood-using industries and home builders.

What are the possibilities in Pennsylvania? Almost half (45 per cent) of our State is in absolute forest land—13 million acres out of 29 million total area. Sample plots show that select areas may produce 90 cubic feet (1 cord stacked) of wood per acre and year. For state-wide application this must be reduced. Germany's yield tables show that her average acre in perfect management (Qual. *II* forest) should produce 111 cubic feet per acre and year. Some state forests in Germany (Saxony) have been driven to the average production of 93 cubic feet per acre and year, but the production for the entire country is only 49 cubic feet, or 45 per cent of the theoretical yield table possibilities. Allowing for slightly better growth conditions in Pennsylvania, we may place our *possible* increment at 60 cubic feet.[4] This would equal our present consumption (giving a total increment of 780 million cubic feet) and make us self-supporting in wood products, if our future growth is

[4] Bulletin 30, previously mentioned, places this at 90 cubic feet, which is too high.